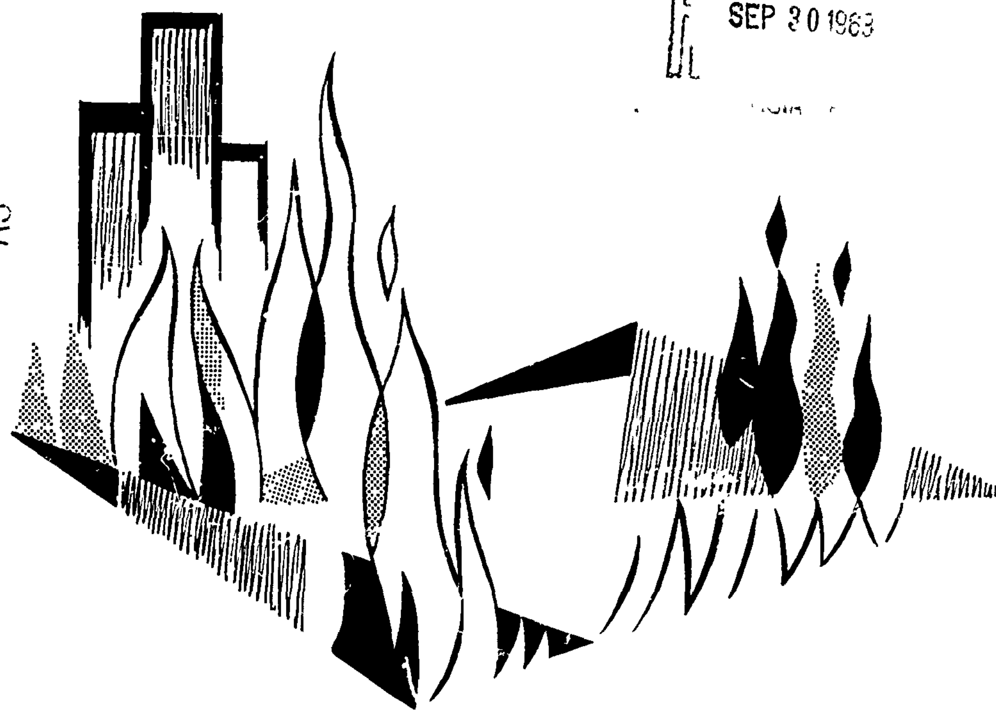
Prediction of Fire Spread Following Nuclear Explosions

(64-3)

Craig C. Chandler, Theodore G. Storey, and Charles D. Tangren



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Final Report
for
Office of Civil Defense
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Pacific Southwest Forest and Range
Experiment Station - Berkeley, California

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Contents

The Authors

Craig C. Chandler is a fire behavior specialist with first-hand experience on more than 30 major fires. After graduating from the University of California with a B.S. degree in forestry (1951), he joined the Experiment Station in Berkeley, taught at the University of California School of Forestry (1953–1956), returned to the Forest Service, and became project leader of conflagration control research at the Pacific Southwest Station. He is the principal author of the sections on wildland fires in this report.

Theodore G. Storey has specialized in forest fire research since joining the Forest Service at Berkeley in 1949. In 1955, he transferred to the Southeastern Station, Asheville, N. C. He worked at the forest fire laboratory in Macon, Ga., for three years before returning to the Pacific Southwest Station in 1962. A forestry graduate of the University of California, he produced the sections on urban fires in this report.

Charles D. Tangren is a mathematician, and prepared the data analyses in this report. He was graduated from California State Polytechnic College in 1961 with a B.S. degree in mathematics. He began working for the Pacific Southwest Station as a research technician, and was promoted to his present position in 1962.

Experience during World War II proved that mass fires can produce casualties and physical damage equal to or greater than those caused by conventional high explosives *(16)*.[1] The atomic bombs dropped on Hiroshima and Nagasaki started fires that burned a total of more t[illegible] 5 square miles in the two cities *(138, 139)*. With the development of multimegaton nuclear weapons, the area exposed to immediate ignition and subsequent burnout has been increased to between 450 and 1,200 square miles, depending largely on weapon yield and height of burst *(84)*. Furthermore, the area over which fire might ultimately spread from a single nuclear explosion has been estimated to be as great as 10,000 square miles for selected targets during selected times of year *(72)*. The problem of fire damage prediction has consequently been receiving greater attention.

The sequence of events following an incendiary attack is identical whether the incendiary devices are thermite bombs, atomic bombs, or hydrogen bombs. Numerous small fires are ignited to a greater or lesser distance around the selected target area. These small fires may or may not merge to form a single mass fire. If a mass fire forms, it may remain confined to the area initially ignited (firestorm), or it may develop a moving front (conflagration) and spread appreciably beyond the initial ignition area.

Much is known about the ignition of urban and wildland fuels following small nuclear detonations *(54)*. For weapons in the kiloton range, the distances to which fires can be expected to be ignited directly by the thermal flash are known relatively accurately *(101)*. But ignition radii become increasingly uncertain as weapon yield increases. This uncertainty arises primarily because of the questionable effect of atmospheric attenuation at distances approximating the optical visibility distance. For a 10-megaton air burst and a 15-mile visibility, the ignition radius can be variously calculated to be from 11 to 18 miles, and for a 100-megaton air burst, from 17 to 28 miles *(82)*.

The question of whether a mass fire will be produced within the area initially ignited has also been studied for both urban and wildland targets *(124)*. The formation of mass fires depends primarily upon the presence or absence of multiple ignitions in areas of high fuel concentration. This question is academic for multi-megaton weapons because susceptible locations will be found within nearly all possible target areas, and the development of several mass fires somewhere within the initial ignition area is virtually certain.

The problem of whether a mass fire from a particular nuclear attack will be of the stationary or moving variety has received only cursory attention, as has the question of how far and how fast such a fire might spread from the area of massive initial ignition. In 1957, as part of the rural fire damage assessment study, the Forest Service prepared a series of tables and maps for predicting the maximum extent of spread of mass fires occurring at various times of year in the continental United States *(129)*. This work was extended and the computational methods simplified in 1960 *(72)*.

As presently constituted, this method of assessing fire damage has two limitations: First, the predictions cover only the probable maximum final area of burnout, and the rate of burnout or the area burned at any particular time cannot be determined. Second, the mechanics of the system are incompatible with the damage assessment system currently used by civil defense planners to predict damage from blast, radiation, and fall-out. In addition, some assumptions used in developing the fire damage predictions have been questioned in recent testimony before Congressional committees *(61)*.

In 1962 the Office of Civil Defense, U.S. Department of Defense, contracted with the Forest Service, U.S. Department of Agriculture, and with United Research Services, Inc., Burlingame, California, to prepare a mathematical model of mass fire spread compatible with the damage assessment system. The Forest Service was to isolate and identify the specific parameters significant to the spread and intensity of mass fires, suggest methods of measuring and codifying these parameters, and collect specific input data to be used in testing a predictive model of fire spread. United Research Services was to develop the models to be tested. This is a terminal report covering the activities and results of the Forest Service part of these studies.

[1] Italic numbers in parentheses refer to Literature Cited, p. 33.

Scope and Assumptions

This study is confined solely to predicting the rate, duration, and extent of spread of mass fires from the area of initial ignitions that may occur following nuclear attack on the continental United States. The factors affecting the extent of primary and secondary ignitions from a nuclear explosion are beyond the scope of this paper. The factors governing the coalescence of small fires starting from these initial ignitions into a mass fire are of secondary importance to this study and are discussed only briefly.

Certain assumptions are implicit in our approach to the problem:

1. Small fires will occur as a consequence of a nuclear explosion.

2. Fire spread following nuclear attack will be controlled primarily by natural factors and will be relatively independent of firefighting efforts.

3. The rate of spread of mass fires following nuclear attack will be identical to the rate of spread of large area conflagrations that have occurred in the past in identical fuel, weather, and topographic situations.

The third assumption requires explanation since it has been widely asserted that the mass fires originating from nuclear explosions in the megaton range will cover hundreds of square miles, an area much greater than any fire before experienced. The argument further runs that such enormous fires will also show behavior characteristics and rates of spread never before experienced.

Admittedly, mass fires within the area initially ignited may be larger than any heretofore known. But we have reason to believe that the spread of such fires out from the area of initial ignition will be governed by the same factors, acting in the same way, that govern the spread of other large area fires. Single fires covering hundreds or even thousands of square miles have occurred many times in history. As recently as 1950, fire burned over almost 2 million acres (3,000 square miles) east of Fort Yukon, Alaska *(80)*. In 1923 an earthquake in Tokyo started at least 80 fires within a few minutes; the resulting conflagration burned out 12,000 acres of central Tokyo *(74)*. Data from such fires should be directly applicable to the problem of predicting the spread of mass fires resulting from nuclear explosions.

Theory also supports the assumption that fire behavior in mass fires resulting from nuclear attack will not differ essentially from the behavior of "normal" large-area fires. Calculations have shown that the violent indrafts so characteristic of a firestorm can penetrate only from about a quarter to a half mile into the fire area *(19)*. Inside these limits, mixing with the atmosphere comes from above rather than laterally. One of the primary characteristics of a mass fire is its ability to produce a convection column reaching thousands of feet into the atmosphere. Mass fire behavior is often controlled by characteristics of the upper atmosphere that have no influence on smaller fires without a well defined convection column. Active fires of 600 to 800 acres in heavy fuels often produce convection columns that rise 25,000 feet or higher Since about 70 per cent of the mass of the atmosphere lies below this altitude, these fires are exposed to all the factors that are expected to affect fires, no matter how large. Thus, for fuels in the center of a mass fire a mile or so in diameter, the fire is already infinitely large and no new factors are expected to influence significantly the environment within the fire zone even were the fire ten or a hundred or even a thousand times larger.

There are numerous, documented examples of fire behavior in mass fires of this size. One example is the Stewart fire near the town of San Juan Capistrano, California, in December 1958 (fig. 1). At the time this picture was taken, the fire covered an area of slightly over 60,000 acres, or almost 100 square miles. The mass fire in the foreground scales 1.4 miles across and 0.6 miles deep, all actively burning at the same time. A second area of mass fire can be seen in the right background, 11 miles away from the nearer portion of the fire.

This situation — several mass fires scattered throughout a much larger burning area — will probably be more typical of the first 12 to 24 hours following nuclear attack than is the often postulated picture of hundreds of square miles going up in flames at once.

Within any likely ignition radius some areas will be free of kindling fuels, some areas will be shielded from thermal radiation by hills, and some areas will be protected from ignition by the screening effect of tree and brush foliage. Thus, sizeable portions of the target area will not be ignited immediately. Even within the areas initially ignited, differences in fuel arrangement and ex-

Figure 1.—Stewart Fire, Cleveland National Forest, California, December 17, 1958.

posure can be expected to affect the rate of fire buildup, and some areas likely will have burned out before fires in other areas have merged to form a mass fire.

Even under the most severe situation imaginable, in which hundreds of square miles of unbroken, homogenous fuels are ignited simultaneously, the period of active burning will not exceed a few hours. Once the central area has burned out, the remaining fire perimeter will spread in the same way as any other wildfire. Though there are obviously some uncertainties in predicting the rate of outward spread during the first few hours, it is unlikely that actual spread will differ from the predicted spread by more than a mile or two. Since there is at least a 4-mile uncertainty in predicting the radius of initial ignitions from weapons in the megaton range, errors in predictions of rate of spread will be well within the limits of error imposed by other components of the damage assessment model.

Determinants of Fire Behavior

Small Wildland Fires

Research into the mechanisms governing the ignition, spread, and intensity of forest fires in the United States was begun by the Army Signal Service in 1881 *(119)*. Investigations into the meteorological determinants of forest fire behavior were continued by the Weather Bureau after its establishment in 1891 and intensified with the organization of the Fire Weather Service in 1916. As early as 1915, the Forest Service began burning experimental fires under carefully measured conditions to determine the influence of various fuel, weather, and topographic factors on the rate of fire spread *(107)*. By 1939 serious attempts were being made to determine scaling laws for forest fires by burning idealized forest fuels under controlled conditions in wind tunnels *(41)*.

Considerable literature on the parameters that affect the spread of forest fires has been published, most of it listed in half a dozen bibliographies *(57, 76, 85, 122, 143)*.[2] Nearly all of it falls into one of these categories:

1. Statistical correlations between various fire characteristics and various parameters of fuels, weather, or topography.

During the past 50 years, analyses have been made correlating the occurrence and size of forest fires with every conceivable variable from sunspots *(21)* to ocean water temperatures.[3] Much of this work can be useful in determining which areas of the United States will be particularly vulnerable to fire damage following nuclear attack, and in predicting the most critical times of year for each area. But most of the results have been too gross to be useful for predicting the behavior of individual fires, and very few of the correlations have used synoptic parameters which are themselves predictable on a day-to-day basis *(102, 103)*.

2. Measurements of fire spread in model fires burned under controlled conditions.

Although modeling studies have been conducted sporadically since 1939, this work has been greatly intensified in the past few years following the establishment of forest fire laboratories in Macon, Georgia, and Missoula, Montana. Laboratory research of this type has done much to increase our understanding of the mechanics of combustion in cellulosic fuels, particularly in defining the properties of fuels that affect rate of fire spread *(7, 47)*. But as yet no scaling laws have been developed that will enable the accurate prediction of rate of spread of large area fires. In view of the extreme difficulties in modeling heterogeneous fuel mixtures and several of the important atmospheric variables, direct application of laboratory results to large-area fire behavior prediction appears several years away *(14)*.

3. Measurements of fire spread on test fires and naturally occurring fires burning under controlled conditions.

Most of the present knowledge concerning rates of spread of forest fires has come from the thousands of test fires and instrumented wildfires that have been studied since 1915. One would expect that such data would be directly applicable to the problem of predicting fire spread following nuclear

[2] Dietrich, J. H. A bibliography on fire behavior, fire danger, fire effects, and fire weather. 1952. (Unpublished master's thesis on file at Univ. Wash., Seattle.)

[3] Robinson, D.D. Relation of ocean-surface temperatures to fire hazard. 19... (Unpublished master's thesis on file at State Univ. of New York, N. Y.)

attack. Unfortunately, . ch is not the case.

Three criteria have en commonly used to easure rate f spread : forest fires: (a) area growth acres per h r); (b) rate of perimeter increase (chains per ur); and (forward rate of spread of the head or fastest moving portion of the fire (feet or ch. s per hour). Figures on area growth or perimet increase cannot be converted to linear radial ra of spread unless the size and shape of the fire at e beginning and end of the selected time period a known. This problem is not particularly seriou for small fires when spread rates are measured fro a point source, but for larger fires over long tim periods, geometry poses formidable difficulties making realistic spread-rate conversions *(70)*.

Thus, although we have c siderable data at our disposal, we have little inf mation that is directly applicable to the civil de nse fire problem. We can use much of it indirec ly, however, and some of the data are useable if w bear in mind the mistakes inherent in direct appli tion. For example, directly applying rate of fo ward spread to predict radial spread results auton tically in overestimating fire size, but we belie that forward rates are useful for establishing he effects of weather, fuel, and topographic var bles, and for determining the maximum rates which fires could be expected to spread. To see f this would be useful to civil defense fire proble s, however, we first wanted to determine whethe data from test and small wildfires would be a licable to larger fires.

A comprehensive study on rates of pread of fires in California was made by Abell in 40 *(5)*. He analyzed data from more than 9,500 f s that occurred between 1925 and 1937. These dat how that the average rate of spread of fires burni in chamise and mixed chaparral (shrub vegetat types) in southern California w s 0.13 mile pe hour; 10 percent of these fires spread f ter th n 0.34 miles per hour, and 5 percent spread faster than 0.52 miles per hour.

These data were obtained by determining the rate of spread from the time the fire was discovered to the time the fire was attacked by fire control forces, nearly always in less than 2 hours. We decided to get similar data for larger fires that lasted for some time because the fires studied by Abell were small and the time periods short. We determined the forward rate of spread for 12-hour periods for 50 fires th . burned in the same area and the same fuel type as the fires studied by Abell. Each fire covered more than 300 acres. We found an average spread of 0.133 miles per hour; five fires (10 percent) spread faster than 0.33 miles per hour, and two fires (4 percent) spread faster than 1.50 miles per hour. Evidently, fires in this fuel type are neither time-dependent nor size-dependent within the time and size limits of interest. Consequently, it is worthwhile to examine the factors that are known to affect the rate of spread of small forest fires.

Weather

Certain weather elements, particularly wind velocity and fuel moisture content, have been established as being the primary controls for the spread of small forest fires. Several systems of integrating the effects of these elements have been developed. The most common systems are described in various textbooks, such as that by Davis *(38)*, and the historical development of these systems has been reported.[4]

Fire Danger Rating

Schroeder *(104)* has given a particularly good account of the way in which a fire danger rating system is developed:

"The relationships between fire behavior and the factors that affect it are so complex that no system can take all of the factors, such as risk, fuels, topography, and weather, into account. Weather is the most variable and the most difficult to estimate. This system was based on weather variables and the resulting rating number called a 'burning index' so as not to imply that all factors were included. The burning index indicates the burning condition of the fuels due to weather variables.

"Since the relationship between the weather variables and fire behavior is so complex, it was necessary to make certain simplifying assumptions in order to devise a workable fire danger system.

"1. While there is an almost infinite number of kinds and fuel sizes, it was assumed that there ... fuels composed of only three sizes:

a. Fine fuels, whose moisture content changes quickly with changing weather conditions.

[4] Pirsko, A. R. ... history, development and current use of forest fire dan... meters in the United States and Canada. 1950. (Unpublished master's thesis on file at Univ. of Mich., Ann Arb...)

b. Medium fuels, whose moisture content can be represented by the moisture content of ½-inch sticks.

c. Heavy fuels, such as logs, large limbs, and deep duff.

"2. While most natural fuels contain combinations of these fuel size classes, the fire is carried primarily in the fine fuels. Therefore, it was assumed that the rate of spread calculated for fine fuels applied to all fuel types.

"3. While the fire intensity in fine fuels certainly varies, the size of the control job is largely determined by the rate of spread. Therefore, it was assumed that for fine fuels the rate of spread is an adequate measure of the control job.

"4. Finally it was assumed that the change of fire intensity resulting from the involvement of more medium and heavy fuels in the fire is of such magnitude that it will affect the fire control job.

"With these assumptions, the development of a fire danger system based on rate of spread and intensity involved the following steps:

"1. Devising a method of estimating the moisture content of fine dead fuels.

"The moisture content of these fuels responds quickly to changing weather conditions. The relative humidity of the air gives a good indication of their equilibrium moisture content. Therefore satisfactory results could be obtained by combining relative humidity with ½ inch stick moisture content.

"2. Determining the effects of fine fuel moisture content and wind speed on the rate of fire spread and combining them into a spread factor.

"A rate of spread formula was developed from theoretical considerations. Data from previous wind tunnel fire tests were then used to obtain empirical values for some of the unknown factors in the formula. From the formula, a family of curves was obtained which represented the relationship between fuel moisture, wind speed, and rate of spread for fine fuels. The latter was changed to an index number, called the spread factor, and a table was constructed to compute it.

"3. Determining a method for estimating the moisture content of heavy fuels.

"Moisture content for medium fuels can be measured directly from ½-inch stick moisture content. Heavy fuel moisture and ½-inch stick moisture records were kept simultaneously and the relationship graphed. The resultant values were combined with precipitation records to give an estimate of heavy fuel moisture.

"4. Determining the effect of green plant material on the moisture content of the whole fuel complex.

"In grass fuels, Forest Service fine fuel moisture figures apply, with adjustments, for percentage of green versus cured content. In brush, it was found that the number of days since new growth can be used as a measure of the moisture content of new brush growth.

"5. Combining the effects of moisture contents of green material, medium fuels, and heavy fuels into intensity factors.

"The fire intensity will increase as medium and heavy fuels dry out. When these fuels are very wet, the effect is believed to be such that the fire intensity is actually less than it would be if only fine fuels were present. Therefore, the effects of the moisture content of medium and heavy fuels were combined in one table to give an intensity factor.

"6. Combining the spread factor and intensity factor into a burning index.

"The length and width of fireline were used to obtain a measure of the control job. The spread factor is the rate of perimeter increase and can be used as a measure of the length of line needed to contain a fire. The intensity factor is a measure of the width of line needed. The control job can be thought of as the number of square feet of line required, or the length of line multiplied by the width of line.

"The use of index numbers, rather than measures of the actual rate of spread, intensity, or control job allows for application to other than the model fuels originally assumed provided that changes in the fire behavior of both natural fuels and model fuels have the same relationship to the index number."

Rates of fire spread and fire danger rating index numbers are correlated in most fire danger rating systems. Figure 2 shows the variation in rate of perimeter increase versus fire danger index for three commonly used fire danger rating systems.

Fuels

Fuel characteristics are known to be extremely important in controlling rate of spread in forest fires, but systems for integrating their effects have been largely unsuccessful.[5] Although laboratory

[5] Chandler, C. C. The classification of forest fuels. 1951. (Unpublished master's thesis on file Univ. Calif., Berkeley.)

studies have yielded much information about the influence of such fuel particle properties as moisture content *(59)*, thermal absorptivity *(26)*, specific gravity *(46)*, and particle geometry *(42)*, the characteristics of the fuel bed, rather than those of the individual particles, determine the behavior of an established fire *(145, p. 819)*. The association of living and dead woody materials of various sizes and shapes that make up the fuel bed in a forest fire is extremely complex. Few techniques have been developed to measure or even describe its properties. Consequently, studies on rate of spread in different fuel types have used only such gross descriptions as "grass", "brush", and "timber" to differentiate between fuels.

An additional difficulty in classifying fuels for evaluating rate of spread arises from the fact that differences between fuels also are weather dependent. Because of the rapidity with which they absorb moisture, thin fuels, such as dried grass, will not support combustion when the relative humidity rises much above 80 percent. But once fires in larger-sized fuels in brush or forested areas are started, they will continue to spread at significantly higher humidities. On the other hand, when humidities are low, grass fires spread significantly faster than brush or timber fires. Under extremely dry and windy conditions, differences in rates of spread between fuel types are minimized.

Nevertheless, under known weather conditions, differences between rates of spread of small fires in various fuel types appear consistent. Figure 3 shows the relative rates of spread of fires in various fuel types in California and in Idaho-Montana under "average bad" weather conditions. Similar comparisons have been made for typical fuel types of the Eastern and Southern United States, where the predominance of deciduous trees makes simple graphical representation more difficult *(125, 126)*.

Topography

Topography has a significant, though usually indirect, influence on the rate of spread of small fires. It controls the amount and timing of solar radiation reaching the surface of a particular area and thus profoundly affects the microclimate within which a fire will burn *(45)*. Microclimate also influences the species of plants that will grow on a particular site, and thus topography may exert an indirect control on fuel type. This influence of altitude and aspect on fire behavior has been studied exhaustively *(40, 60)*.

Slope has a direct effect on the rate of spread of small fires. For a fire climbing up slope, the rate of forward spread will approximately double for each 15-degree increase in slope *(131)*. For a fire moving down a steep slope, the relationship is not so simple. A fire will move more slowly downslope than on the level unless burning fuels, such as pine cones or logs, roll downslope ahead of the main flame front.

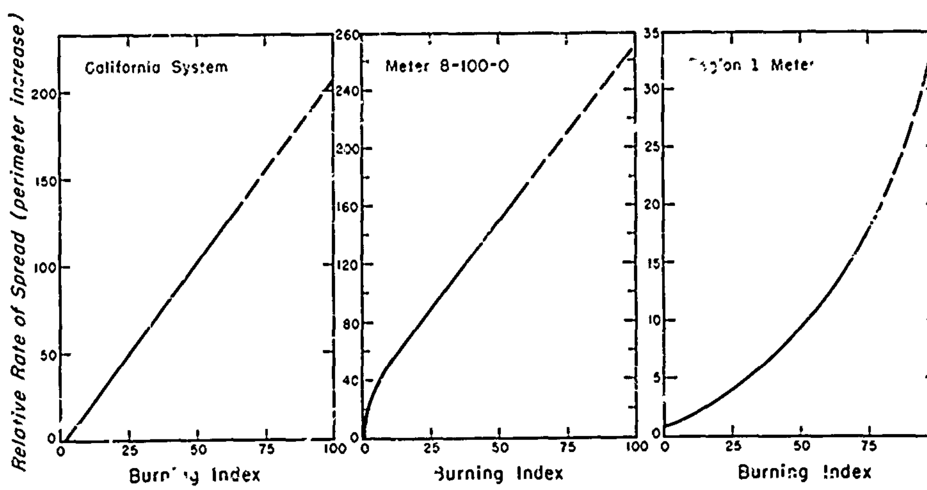

Figure 2.—Relative rate of fire spread by burning index (all fuel types combined).

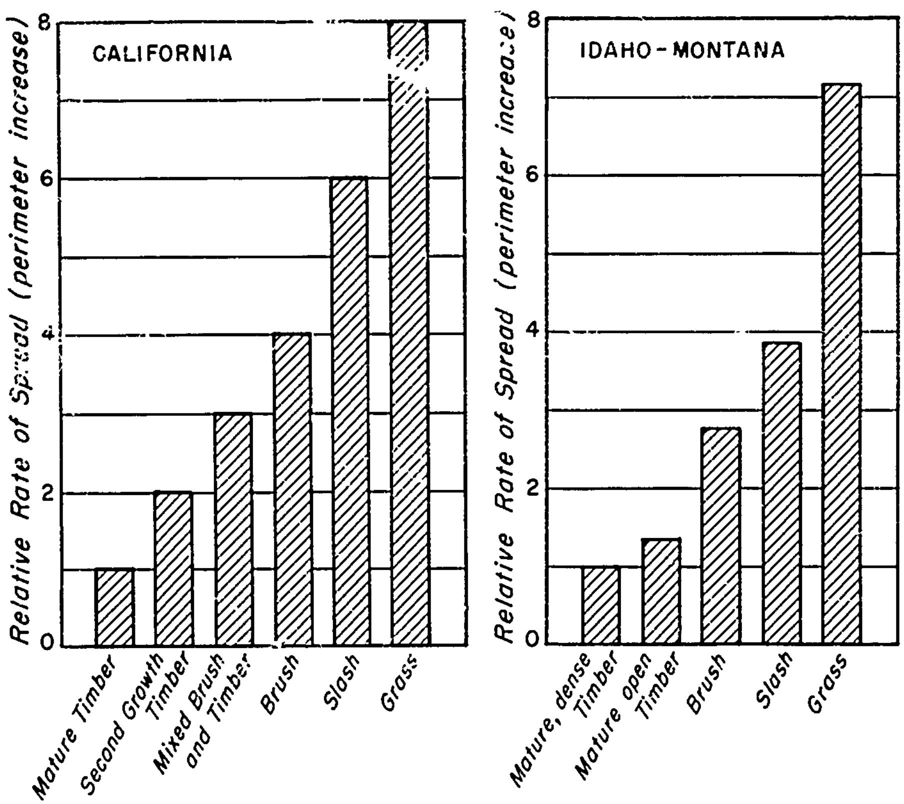

Figure 3.—Relative rate of fire spread, by fuel types.

Small Urban Fires

Research in urban fire behavior was begun by Suzuki in Japan in 1928 *(109)*. He studied the effect of weather factors on the occurrence of fires, spread of fires, and the rate of burning of hygroscopic incense sticks. Others also analyzed case histories of fires to determine the effect of weather factors *(111)*. This work was discontinued during World War II. After the war, some fire-modeling of convection *(148)* and flame shape *(94)* were started. The emphasis in Japan today, however, is still on the study of actual conflagrations for probable occurrence and spread in relation to the weather *(74)*.[6] Such studies are numerous *(6, 53, 58, 62, 65, 68, 73, 147, 149)*.

Urban fire behavior research in the United States probably began with the work of the National Fire Protection Association. This organization, founded in 1896 *(37)*, publishes tabulations of those weather and fuel factors which contribute to conflagrations *(37, 90, 91)*. These tabulations are based on case histories of hundreds of fires studied by the Association itself *(83, 88, 89, 90, 92)*, the National Board of Fire Underwriters *(99)* other organizations of underwriters *(30, 108)*, interested laymen *(8, 31, 49, 86)*, and the Weather Bureau *(35)*.

After World War II, the U.S. Strategic Bombing Survey (U.S.S.B.S.) studied the fire effects of the incendiary and nuclear attacks on Japan *(137, 138, 139)* and Germany *(136)*. These reports have been analyzed extensively for clues as to how fires might spread in any future war *(16, 17, 78, 116, 123)*. The British Mission to Japan also reported on the fire effects of the two atomic bombs in relation to possible similar fires in Britain *(1)*.

[6] Personal correspondence with Dr. Saburo Horiuchi, Fire Research Institute of Japan, Tokyo, April 25, 1962.

In 1950 British scientists began studying the spread of fire from building to building *(2, 77)*. Model studies of fire spread inside buildings began about 1960 with the work of Thomas *(112)*.

Since 1953 the Forest Service has done considerable work on the ignitions of wildland and exterior and interior urban fuels by atomic attack *(28, 100, 128)*. It has participated since 1957 in studies aimed at modeling areas of burnout after nuclear attack on wildland and urban targets *(129)*. Some pioneer work on a fire occurrence rating system for cities was done by Pirsko and Fons in 1956 *(96)*. In 1961 Fons began fire model studies by burning liquid hydrocarbons *(43)* and, later, crib fires *(48)*.

Thus, considerable literature has been published on the parameters affecting the ignition and spread of urban fires. Nearly all of these data fall, like those for wildland fires, into one of three categories:

1. Statistical correlations between various fire characteristics and various parameters of fuels, weather, topography, or location.

In Japan, several investigators have made correlation analyses of number and size of fires as influenced by particular aspects of weather, fuel, or season *(58, 73, 109, 111, 147)*. Much of this work has been useful in determining which areas are vulnerable to fire and in predicting the critical times of the year for each area. But most of the results have been too gross to be useful in predicting the behavior of individual fires. Also, few correlations have used synoptic parameters which are themselves predictable from day to day. Of course, quantitative results of analyses such as these would not necessarily be applicable in the United States.

In the United States, statistical analyses of urban fires are confined almost exclusively to frequency distributions of number and size of fires by months, season, cause, locality, or similar categories *(37, 90, 91)*. Such tabulations are satisfactory for their intended purpose but are of little use in predicting rate of spread. The most useful U.S. research of this type related frequency of building fires in selected cities to relative humidity in summer and dewpoint temperature in winter. It found no sigficant correlations with wind, rain, or snow *(96)*.

2. Measurements of fire spread of model fires burned under carefully controlled conditions.

As yet no complete urban fire spread model is reported in the literature. Some theoretical computations on behavior of fires in buildings have been reported *(113)*, and spread of fire in individual rooms *(112)* and model rooms *(114)* has been studied to a limited extent. Modeling studies of mass fires using gas jets have been made by Putnam and Speich *(98)*. Fons is now modeling fire spread in small wood cribs and determining the influence of weather and fuel *(44, 48)*. This type of laboratory research, like that for wildland fires, is still a long way from application.

3. Measurements of fire spread on test fires and naturally occurring fires burning under controlled conditions.

Only in Japan have radial rates of spread of actual city fires been related to the controlling variables of weather, fuels, and topography. The works of Hishida *(62)* and his successor, Hamada, are considered the most reliable.[7] Hishida found that wind speed was the most important factor in predicting forward rate of spread of city fires as well as spread to windward and the flanks.

Hishida also recognized the effect of synoptic weather conditions, climate, topography, and types of construction on rate of spread. Forward rate of spread in buildings of flimsy construction was computed as 40 percent greater than in buildings of ordinary construction. Hishida based an urban risk rating system on this data and proposed a tentative urban fuel classification system. Horiuchi developed a formula for estimating the capacity of the city fire department *(65)* based on Hishida's spread data.[8]

The U.S.S.B.S. reports for World War II contain no data on rate of fire spread. Some give the final fire perimeter or the limits of fire spread, but usually the ignition area is very uncertain. Fire researchers in Japan consider the data taken by their own people during the attacks and subsequent fires and the U.S.S.B.S. data so unreliable that they do not use these data in their own studies *(74)*.[9] However, the information has value to us in indicating limits to which fires in similar fuels and weather might be expected to spread.

Fire data in the U.S.S.B.S. reports for Germany are also incomplete and sometimes unreliable *(79)*.

[7] See footnote 6.

[8] We might wonder why the Japanese are not studying urban fires and fire spread from the standpoint of defense against possible nuclear attack. The answer is that the thought of another nuclear experience is so repugnant to the public that research agencies cannot get support for such work even though it might be prudent to start such investigations. (See footnote 6.)

[9] See footnote 6.

The area ignited initially is usually poorly defined on the fire maps, although the final fire p[illegible]er is sometimes distinct. Because the larger cities were partially burned on many successive raids, accurate fire maps were difficult to produce.

Ignition

Although one assumption of this study is that fires will be burning and will spread, a word on ignition of city fires is in order.

It is fairly well established that the number of urban fire starts depends heavily upon interior fine fuel dryness and that fuel dryness depends upon the humidity of the air in the building *(58, 96)*. Forest fire occurrence is also closely related to fine fuel dryness *(104)*, although fuels in these instances are in different forms. Pirsko *(96)* has found that in several American cities summer fine fuel moisture and fire occurrence are closely related to relative humidity, but that in the winter there is no correlation. Instead, during the winter, fine fuel moisture and fire occurrence are closely related to exterior dewpoint temperature. For these and other reasons, fire seasons in urban areas and forests do not usually coincide. There is no fire occurrence rating system for cities as there is for forests *(104)*.

According to the U.S.S.B.S. reports, the major influence of wet weather on fire raids on Japan and Germany was in reducing initial ignitions rather than impeding fire spread.

Spread

Once a fire has started, radiation and other factors determine how it spreads inside the room from room to room, and from building to building *(106)*. From the work of Hishida *(62)*, we know that the forward rate of spread of fires in small Japanese cities of ordinary construction increases at a decreasing rate from origin to about 1 hour for all wind speeds. At wind speeds of 15 miles per hour or less, the rate of spread levels off at about 1 hour from origin. At wind speeds of about 40 miles per hour or greater, rate of spread continues to increase for more than 2 hours. Spread rate increases exponentially with increasing wind up to 55 miles per hour for all fire durations. Of course after 2 hours or longer, a fire burning under such conditions could no longer be classified as small. Rate of spread to windward and to the flanks is also known *(62)*, the former having the lowest rate of the three directions of spread. Rates of spread to windward and leeward level off after about 1 hour elapsed time from origin for all wind speeds. This result is expected because fire is less actively burning in these two directions. Hishida's results agree reasonably well with observations on both small and large urban fires in the United States.

Weather

Most investigators agree that surface wind speed is the most important weather factor influencing the spread of small urban fires *(62, 73, 111, 149)*. Once a fire in a building breaks through the roof or windows, its spread is largely wind controlled. The moisture content of the flammables in the building and the wetness or dryness of the exteriors of the building and adjacent buildings have some effect, but these are second-order determinants. Studies of the incendiary attacks on Japan during World War II *(16)* showed that precipitation had very little effect in reducing fire damage. As Nathans *(16, pp. 143-144)* put it: "... However, these factors (snow, rain, and generally moist conditions) did not offer the serious handicaps that had been supposed." Sanborn *(16, p. 178)* wrote: "When the weather had been damp or snowy prior to the attack, the attacks were found to be slightly less effective. When attacks were carried out during rain storms, the damage averaged 20 percent less than normal . . ."

Rain fell heavily for a week before the fire raid on Oita, Japan, and it was raining during the attack. Yet the fires spread, both from flames and from flying embers. Many other night raids on Japanese cities during wet or snowy weather caused vast spreading fires. In no case did rain, snow, or a wet target prevent the success of the bombing mission.

In the opinion of the fire chiefs of 17 large American cities interviewed during the present study, fires spreading from nuclear attack in their cities would be slowed down only slightly by wet weather or wet fuels in the absence of fire fighting. In their experience, high wind is the most important contributor to conflagrations. Wide spacing between buildings would be the most important factor in stopping fires, they suggested.

A counterpart to the fire spread index for forest fuels *(104)* that integrates the influence of wind, humidity, and other weather elements has not been developed for urban fuels.

Fuels

The characteristics that are important in determining the spread of fire in small groups of buildings are height, width, type of construction, window area, and separation from adjoining structures. In small fires, spread is by radiation, direct impingement of flames, and short distance spotting from firebrands. The fire is influenced only by surface weather phenomena. As the fire grows, flames from many burning buildings merge, a tall convection column forms, and a mass fire ensues

Theoretical and experimental studies have been conducted in Japan to determine the flame characteristics of burning structures and ignition characteristics of exposed structures to determine safe clearances between buildings as a basis of fuel typing *(53)*. From analyses of fire raids on German cities, Bond *(16)* and U.S.S.B.S. investigators *(127)* constructed curves of probability of fire spread versus width of firebreak. Their work has not been checked experimentally.

Most of the 17 fire chiefs interviewed believe that a simple land use classification system, such as those already in use in some urban areas *(3, 4)* or that devised by Chandler and Arnold *(28)*, would indicate with reasonable accuracy the relative probability of fire spread. In general, such classifications reflect most of the factors recognized by the National Fire Protection Association as contributing to conflagrations *(37, 91)*. Important factors include flammable roofs, wind, extreme dryness, and flammable construction.

Topography

Among topographic factors, slope probably has the greatest influence on rate of spread of urban fires. Most larger cities usually lie on level areas or on gentle slopes. During the San Fancisco earthquake, the fire was observed to accelerate when it started up Russian Hill *(99)*. One account of the fire following the atomic bomb attack on Nagasaki mentions fires "sweeping up hillsides" *(139)*. In the Bel Air conflagration, fire accelerated up hillsides through residences and brush alike. We do not know if the increased spread of a forest fire moving up slope — doubling for each 15 degree increase in slope *(131)* — applies to cities. A forest fire will move more slowly downslope than along the level, and this relationship probably also applies to urban fires.

Topography controls the amount and timing of solar radiation reaching the surface of a given area, and thus exerts a significant effect on the climate near the ground within which a fire will burn. Aspect is important in determining how exposed forest fuels will burn, but it appears doubtful that it has much effect on protected urban fuels.

Large Wildland and Urban Fires

So far we have described only small fires burning for an hour or two after starting from a point source of ignition and influenced primarily by surface weather phenomena. Much less quantative information is available on the factors controlling the spread of large forest and urban fires.

As a fire increases in size and intensity, additional factors influence its rate of spread. Even the mechanism of spread may change if spotting, or the mass transfer of burning materials ahead of the main flame front, occurs.

Although we do not know enough about the factors affecting the spread of large fires to integrate their effects and thus prepare a "large-fire danger rating system," many of the factors have been studied more or less intensively. Merely understanding their qualitative effect on rate of spread can help in predicting the probable fire consequences of nuclear explosions.

Convection

Probably the most striking phenomenon of large forest and urban fires as contrasted with small ones is the increase in convective activity and development of a convection column of hot gasses, water vapor, and smoke reaching thousands of feet into the atmosphere. In fact, the extent of convective activity over a fire is a much better indicator of fire intensity than is the size or surface area of the fire itself. Figures 4, 5, 6, and 7 illustrate various types of convection columns.

Once a convection column has formed over a fire, characteristics of the upper atmosphere begin to influence the direction and speed of fire spread. Embers carried up into the column are transported by upper level winds which may differ drastically in both speed and direction from those at the surface *(144)*. In addition, the convection column itself, because of its difference in temperature and density from the surrounding air, acts as a semi-solid barrier and causes mechanical turbulence in the wind field around the column. Byram *(25)* has

Figure 4.—Towering convection column typical of fires burning in an unstable atmosphere with light winds aloft. Jameson Fire, Cleveland National Forest, California, August 31, 1954.

Figure 5.—Flattened convection column typical of fires burning beneath an inversion. Haslett Fire, Sierra National Forest, California, October 15. 1961.

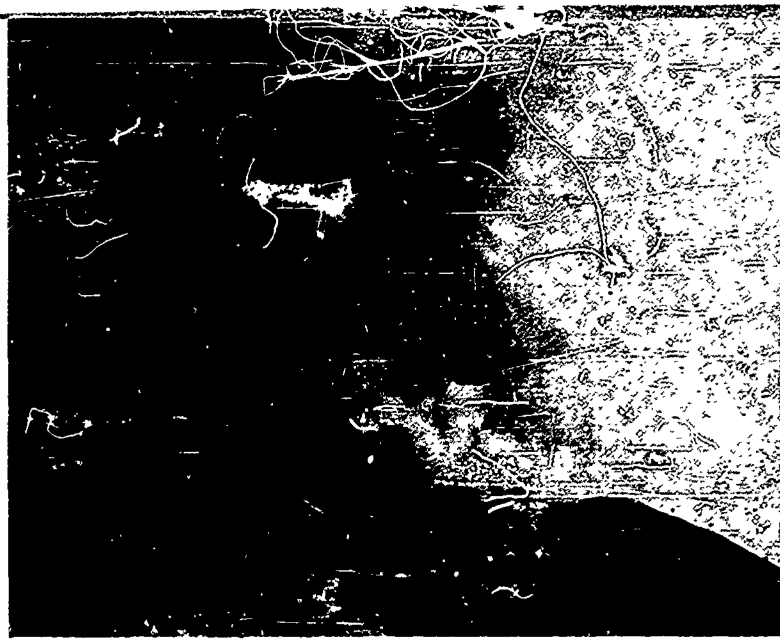

Figure 6.—Tilted convection column typical of fires burning in a conditionally stable atmosphere with moderate winds aloft. Los Angeles County, California, September 22, 1957.

Figure 7.—Tilted convection column typical of fires burning in a conditionally stable atmosphere with moderate winds aloft. San Francisco, California, April 20, 1906.

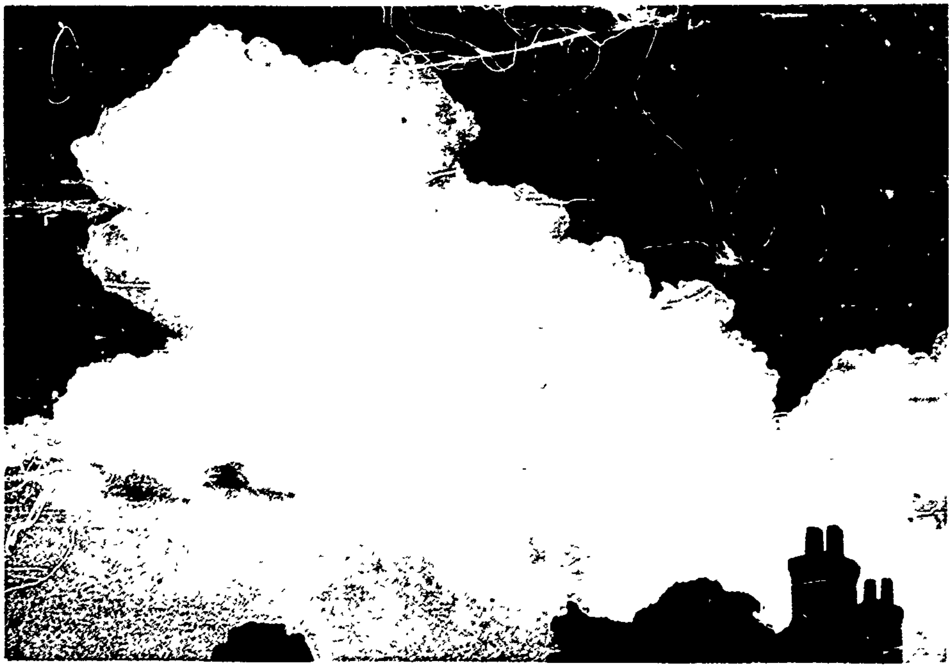

Figure 8.—Cumulonimbus cloud over Bussum, Netherlands, June 17, 1948. (Photo courtesy of Royal Netherlands Meteorological Institute.)

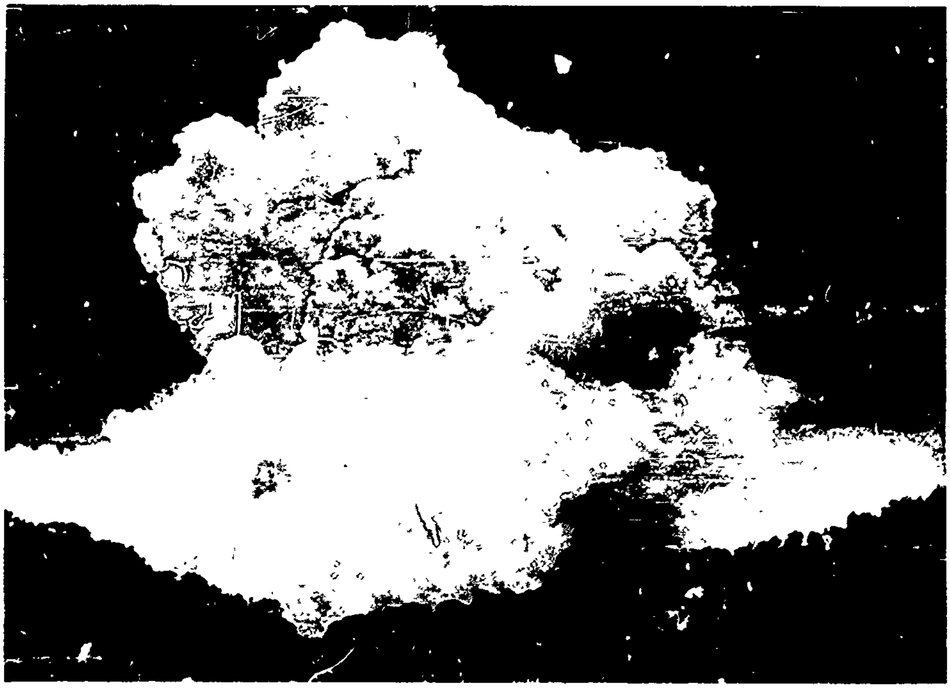

Figure ʻ —Convection column of Basin Fire, Sierra National Forest. California, July 16, 1961.

developed a formula which shows that when

$$\frac{I}{C_p(T_o+459)} > \frac{\rho(v-r)^3}{2g}$$

then the kinetic energy output of a fire is greater than the rate of flow of kinetic energy in the wind field in a neutrally stable atmosphere. In this equation, I is the fire intensity in BTU per foot per second, C_p is the specific heat of air at constant pressure, T_o is the free air temperature, ρ is the air density, v is the wind speed, r is the forward rate of spread of the fire, and g is the acceleration of gravity. Studies of large fires have shown that when these conditions are met, rate of spread is indeed independent of surface wind speed. In theory, spread should then become dependent on winds aloft, but there are, at present, too few measurements of upper winds in the immediate vicinity of large forest fires to support fully this view.

When high velocity winds occur within 1,500 feet of the surface, large fires will spread rapidly in the same direction as the winds *(23)*. However, this phenomenon can be explained by translation of momentum to the surface through turbulent mixing in the lee of the convection column.

Evidence of effects of winds at higher levels, such as the jet stream effects postulated by Schaefer *(102)* seems, as yet, unconvincing.

Although the convection column of a large fire does affect fire spread mechanically, it does not act as a chimney for the unimpeded flow of stack gases as has been popularly assumed. Convection columns are similar to other atmospheric convective cells, such as thunderstorms, whose dynamics are reasonably well understood *(22)*. Indeed, it is often nearly impossible to distinguish between a fire's convection column and a cumulus cloud (figs. 8 and 9).

Work on air entrainment into fires by Grumer *(55)* and studies of the firestorm at Hamburg by Ebert *(39)* both confirm that a massive convection column is a result, not a cause, of increased convective activity. Convection column formation depends simply upon the efficiency of the fire as a heat source and upon the vertical distribution of temperature, moisture, and wind flow that determine all types of atmospheric convections.

Air Entrainment

Knowledge of air entrainment into fires is of vital importance for predicting whether a mass fire will be of the firestorm (stationary front with inflow from all directions) or the conflagration (moving fire front) type. Qualitatively, much can be deduced about air entrainment *(110)*. But quantitatively, results of extrapolation of convective flow from fire modeling experiments are highly dependent upon the assumptions one makes regarding the interaction of radiation and flow *(67)*. Results from test fires and wildfires have been inconsistent. Usually, light indrafts have been observed *(141)*, and wind speeds measured in the lee of the fire have been lighter than the wind speeds measured on the windward side or the flanks. This difference indicates a vectoral tendency for air entrainment from all sides of the fire. But occasionally outdrafts have been observed from both stationary *(117)* and moving *(33)* fires. These outdrafts tend most often to form on the lee side and are apparently uncorrelated with fire size or fire intensity. Strength of the outflow seems to be directly related to the free air wind speeds, but whether outdrafts will or will not occur appears to be independent of weather conditions.

Certain topographic features that produce natural wind channels also seem to produce fire outdrafts that can have a very pronounced effect on rate of spread. In one brush fire in southern California, wind speeds at ground level ahead of the fire were measured at 27 miles per hour while winds at the side and rear of the fire were 12 miles per hour or less.

Another fire, in timber, spread 10½ miles in 2 hours. Observers in front of the fire reported gale force winds blowing out of the fire, but winds measured at some distance from the fire zone never exceeded 7 miles per hour. Figure 10 pictures a wildfire in which outdrafts are evidently blowing from the head of the fire. The oak tree in the center of the picture is about 40 feet tall.

Although completely unpredictable at present, the phenomenon of increased airflow out of a fire may be a common feature of larger fires. Observations made directly in front of mass fires are understandably few, but nearly all eyewitness accounts mention high winds. Even during the fires following air raids on Leipzig and Hamburg (listed as classic firestorms), successful firefighting was possible at selected locations on the perimeter, and heavy smoke was reported outside the fire area in

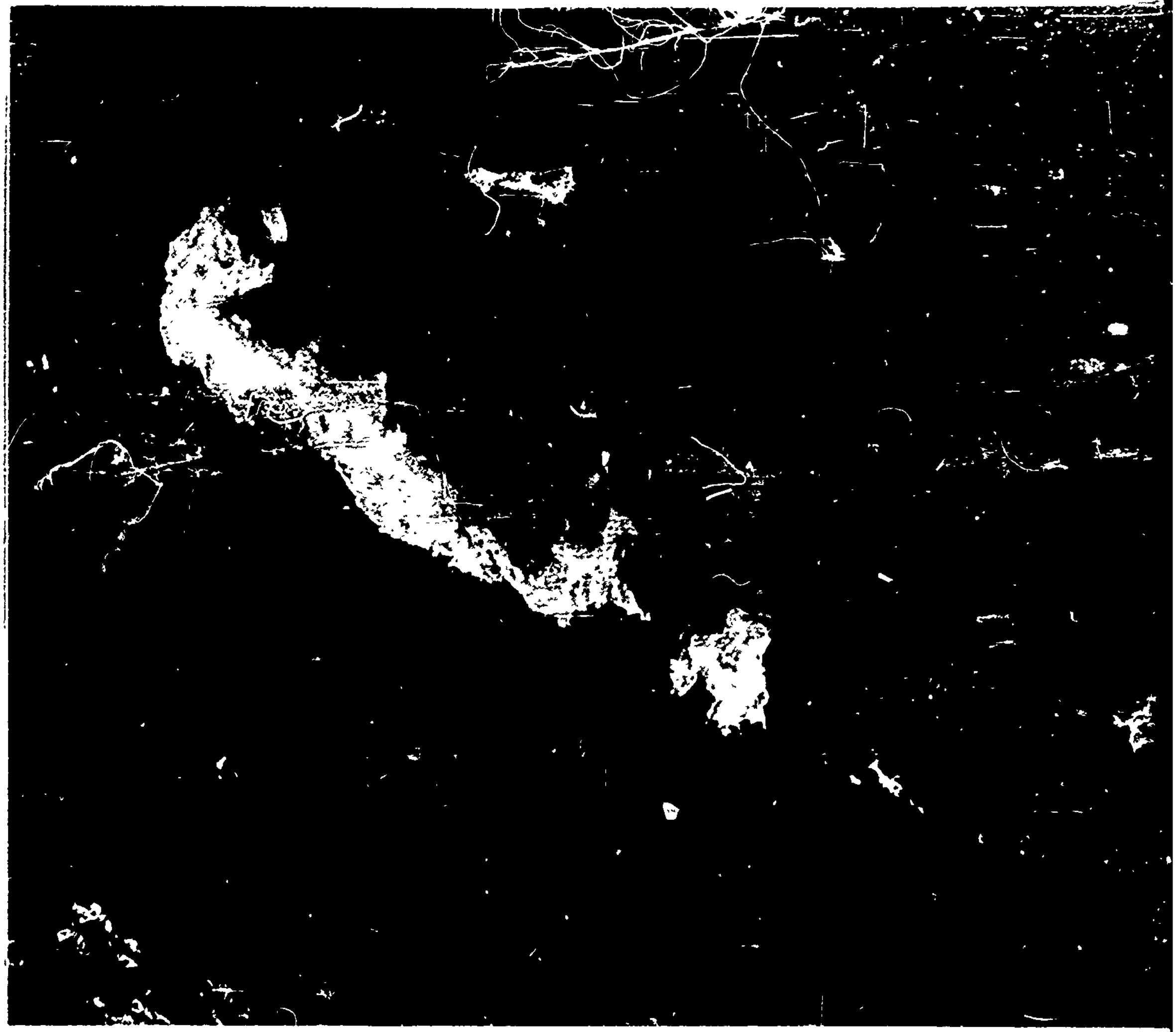

Figure 10.—Nichol Fire, Cleveland National Forest, California, July 11, 1958.

some places. These circumstances indicate that hurricane indrafts could not have been uniform and continuous around the entire perimeter. Analysis of wartime fires leads to the conclusion that the stationary firestorm is virtually limited to situations of fuel and weather in which normal fire spread is impossible *(17)*. Under conditions in which ordinary fires would be expected to spread, mass fires will be of the conflagration type.

Atmospheric Stability

Atmospheric stability is the tendency of the air to resist or encourage vertical motion. It is known to be an important parameter affecting large forest fires[15] and has been postulated as critically important in firestorm formation *(39)* Under an unstable lapse rate, vertical motions are accelerated. Therefore the convection column transports more and larger pieces of burning material to higher levels. If an unstable lapse rate is combined with high wind shear, as occurs during the passage of a dry cold front, conditions are at the optimum for firebrands to be carried long distances *(24)*. Other combinations of stability and wind in the lower atmosphere are associated with particular

[15] Reifsnyder, W. E. Atmospheric stability and forest fire behavior. 1954. (Unpublished doctoral dissertation on file at Yale Univ., New Haven, Conn.)

fire behavior characteristics *(10)*. Because adequate three-dimensional maps of temperature and wind distribution are difficult to prepare, the most [illegible] able method of developing prediction systems for these fire phenomena is by correlating them with predictable synoptic patterns *(69)*. Such an approach is being undertaken by the Forest Service and the Weather Bureau *(133)*.

Fuels

In high intensity mass fires, total weight of fuel becomes of greater relative importance than the factors of size, distribution, and arrangement that are so critical to the spread of small fires. As fire intensity increases, burning time for a particular piece of fuel decreases. Consequently, the rate of heat output per unit of fuel of a given size is greater; larger-sized fuels contribute a greater proportion of the total fire energy, and the percentage of fuel involved in active combustion at any given instant is much greater. The net result is an extremely rapid burnout and nearly total consumption of all combustible material.

Fuel classification systems based solely on fuel weight should give much more consistent results in predicting the behavior of large fires than of small ones. The urban fuel factor of "builtupness" (ratio of the area covered by buildings to total ground area) has been used as an expression of total fuel weight in cities. Although it ignores building height and construction type, this factor was mentioned by Bond *(16)* and, slightly modified, by others *(15)* as the most important factor in determining whether a firestorm can develop following nuclear attack.

Topography

Topogaphy, in its strict dictionary sense of surface configuration of "shape of the country," is undoubtedly an important factor in determining the rate of spread of large fires. Unfortunately, the subject has not yet been systematically researched, and it is difficult even to classify topographic types in a meaningful framework for fire behavior studies. There are strong indications, however, that for periods of 2 to 3 hours, rate of fire spread is greatest in mountainous or broken topography but, for periods of 12 to 24 hours, greatest on flat or gently rolling topography. The difference probably arises because mountainous country has more steep slopes which cause rapid fire spread, but also more breaks or barriers which retard spread for long periods.

Topography is particularly important in considering fire spread following nuclear attack since hills will provide shielding from thermal radiation and result in uneven ignition within the theoretical ignition radius. Fire spread in such instances will be affected by ignition pattern. The differences in behavior between the Nagasaki and Hiroshima fires have been attributed largely to shielding by the hilly country around Nagasaki *(61)*.

Requirements for Predictive Model of Fire Spread

Before attempting to specify the type of data that must be collected to predict fire spread following nuclear attack, we must know the output requirements of the proposed prediction system and the use to be made of the output information. Two general types of use and three levels of output detail have been established as having potential value for civil defense purposes *(95)*. Fire spread predictions are needed for pre-attack planning and for post-attack indirect damage assessment. For either purpose they may be needed on a national, regional, or local level.

For pre-attack planning, a broad base of historical records must be available for all variable factors so that plans can be made on the basis of calculated probabilities. Thus, the availability of data becomes a primary consideration in selecting parameters to be used as inputs in the predictive model.

For post-attack damage assessment, on the other hand, the greatest requirement is that accurate current information be obtainable. In either actual or simulated situations, totally new parameters can be considered — provided that the information can be collected quickly enough and at enough locations to give the desired degree of accuracy.

At a national level, the model output can give fairly gross information on fire spread and still be acceptable, if errors of prediction are unbiased. Inputs based on existing data on fuels, weather, and topography should be sufficient for adequate fire spread prediction on a national scale, either for planning or for post-attack assessment.

At a regional level, a somewhat greater degree

of detail and accuracy is required for both input and output, particularly for critical areas within the region. But again, the predicted spread from any one nuclear explosion may have fairly wide limits of error, if fire spread predictions are accurate for the attack as a whole. For most regions of the United States, there is sufficient input data available for pre-attack planning. But additional comunications procedures for obtaining weather information and some extensive fuel surveys will probably be required for post-attack damage assessment.

Local use of a fire spread prediction system will require the most sophisticated modeling techniques. Input data must be very detailed, and the output must predict fire spread from an individual detonation with a high degree of accuracy. Very few areas of the country have made the intensive land-use and climatological surveys that would be required to provide input data *(120)*. In addition, it is questionable whether the current status of knowledge about fire behavior is sufficient for the construction of a useful model designed to predict the rate and extent of individual fires. For post-attack evaluation, fire behavior specialists could prepare detailed predictions based on their experience and available information by using regional fire spread predictions as guidelines. This approach has proved highly successful in predicting the behavior of large forest fires *(29)*.

Data: Availability and Needs

For any predictive model of fire spread, all input parameters can be assigned to one of three general classes: fuels, topography, or weather. Although this project collected only the data required for one specific model, we did survey the availability of other types of data within these three broad categories A generalized study of the availability of environmental data has been prepared by the U.S. Army Corps of Engineers *(118)*.

Fuels

Information on fuels, per se, is almost completely lacking except for the specialized coverage provided by the Sanborn Maps *(37, p. 617)* for certain urban areas and by the fuel-type maps prepared for selected National Forests *(66)*. Much of this coverage is badly out of date. However, when properly interpreted, data on land-use classification and vegetative distribution can be converted into broad but meaningful fuel classifications.

Several adequate sources of phytogeographic coverage are available for national use. On the broadest scale, "Major Land Uses in the United States," a map prepared by the Bureau of Agricultural Economics *(81)*, can be used to delineate cropland, arid and semiarid areas, alpine zones, and major conifer and hardwood forest types. Similar but more recent coverage is being prepared by the University of Kansas for publication in late 1963 or 1964.[11] The Atlas of American Agriculture *(121)* contains older but more detailed and larger-scaled maps of the natural vegetation.

Except for the largest cities, urban areas would show up only as small dots on even the largest phytogeographic maps of the United States *(121)*. If cities were important to civil defense only in proportion to their area in the United States, most cities could be ignored for predicting fire spread on a national scale and the broadest sort of land use classification would suffice for characterizing fuels in the large cities. However, cities are what we are most intererested in protecting. For national use, the small-scale, general land-use maps available *(64)* for most cities in the United States with 25,000 or more population, should suffice. Scales of these maps usually are larger than 1,000 feet per inch, and the map is contained on one or two page-sized sheets of paper. Usually there are 5 to 10 categories of land use. Most cities also have zoning maps; although these maps show desired or planned, rather than actual land use, they could be used with small loss in accuracy in cities lacking a land use map.

At the regional level, the soil-vegetation maps of the U. S. Department of Agriculture *(130)* and the timber type maps of the Forest Service[12] are excellent sources for fuel typing. In addition, agricultural and other special land-use maps are usually available from the appropriate department of the various states.

[11] Kuchler, A. W Natural vegetation of the United States. (In preparation for publication, Dept. of Geography, Univ. of Kansas, Mo.)

[12] Vegetation type and forest condition maps. U. S. Forest Service, Washington, D.C.

Most cities of 25,000 population or more (of which there are about 480 in the United States) have a fairly large land-use map scaled to 1,000 feet or less per inch. These maps would provide satisfactory detail on a regional level. For heavily populated cities, such as New York, maps may be as large as 8 by 8 feet and have great detail and many use categories. Generally, however, map sizes and number of categories are very similar from city to city. Zoning maps generally are available and, though less accurate, can be used to classify fuels if land-use maps are quite dated or non-existent.

Large-scale aerial photos (that is, photos representing few feet on the ground per inch of photo) probably are not necessary for classifying fuels on a regional level. But in most cities of 25,000 population or more, prints of vertical or oblique aerial photos of the city, sometimes in color, taken by some professional or amateur photographer, can be obtained. Often they appear on large souvenir postcards. These photos can be useful for checking building characteristics, street widths, and other information as an aid to rating fuels.

To be useful on a local scale, fuel mapping must be intensive and should be repeated periodically in the rapidly changing urban complexes and newly developing suburbs. The most feasible method of type mapping in fine detail is through the use of aerial photographs (see Appendix A).

Sanborn Maps used in conjunction with vertical aerial photos probably would be the best source of data for typing or rating urban fuels on a local scale. Sanborn Maps are designed for the use of fire insurance underwriters. They show the location, physical characteristics, and use of most buildings in nearly all cities with populations of 2,000 or more. The maps of the larger cities are revised once a year. The maps are in the form of atlases, averaging four blocks per page, and available at scales of 50 feet and 100 feet per inch. Aerial photographs and photo mosaics have been made for all or part of many cities since World War II. Some urban areas, such as Metropolitan Dade County, Florida, have made enlargements of aerial photos into atlas form with one 30- by 30-inch page covering approximately a 4-city block-area.

Topography

Detailed, accurate topographic maps of most areas of the continental United States are easily obtained. The current status of both topographic mapping and aerial photography can be ascertained through the U. S. Geological Survey or through the National Atlas of the United States *(134, 135)*.

But unlike fuels, topography cannot easily be categorized into classes with both a quantitative and a universally recognized meaning. This problem is of concern to several agencies and recent work on terrain analysis by the U. S. Army *(75, 146)* may eventually result in an acceptable classification system.

In the meantime, such classifications as "broken" or "rolling" should be sufficient for fire spread models for national or regional use.

Topographic maps usually show enough features of the cities to give an idea of the land use. Unfortunately, most of them are rather old and the city features out of date. Most larger American cities are situated on relatively level land, so that topography would not be a factor in fire spread. However, some cities contain hills where topography could be a factor.

Weather

Climatological data on the important surface weather elements are available in almost embarrassing profusion. The Weather Bureau alone has more than 12,000 weather observation stations in its climatological station network *(140)*. Additional weather observations are taken regularly by the military services, by federal and state forestry agencies, by air pollution control districts, by universities, and by private industrial, agricultural, and aviation groups. Measurements of pressure, temperature, and humidity patterns in the upper air are available from 137 locations, 64 of them within the continental U. S. An additional 290 stations make routine measurements of upper air wind velocity and direction.

For national use, the 24-hour Climatic Network (consisting of 179 First Order Weather Bureau and U. S. Federal Aviation Agency stations) provides a well spaced grid of observing stations with uniform standards of observing, compiling, and reporting surface weather data. Hourly observations of precipitation, temperature, dewpoint, relative humidity, wind direction and speed, ceiling, and visibility are available either in published form or on punched cards. Upper air data

are also available, both in published form and on punched cards.[13]

Additional weather coverage should be obtained for predicting fire spread at the regional level. Surface observations from military stations, FAA stations, and fire-danger rating stations operated by state or federal forestry agencies can provide an adequate data base. However, instrument exposure standards, observation times, and reporting procedures differ between agencies. The data should be standardized before being combined for use as inputs for predicting fire spread.

Existing upper air stations are adequate for regional use, except in the Western United States and mountainous regions of the East. In mountainous country, significant variations in upper air patterns have been noted over distances of 200 miles or less *(27)*. Most upper air observation stations are located near the large population centers of each region. Consequently upper air data will be more accurate for many civil defense purposes, particularly in urban areas, than might be expected from the relatively small number of stations.

For fire spread prediction on a local scale, intensive climatological surveys should be made for each area of interest. Rate and direction of fire spread for a particular fire often depend as much on local weather patterns as they do on synoptic weather features *(34)*. Accurate prediction of the behavior of an individual fire, wildland or urban, requires accurate data on these local weather patterns.

Fire Spread

Although fire spread data are the outputs, not the inputs, of the mathematical models, some independent measurements of fire spread are needed to test the models. The data presented in Appendices D and E were collected for another purpose: to determine the relationships between rate of spread and other variables. Consequently, the criteria used to select these data are probably more stringent than necessary for simply testing model output. For this and other purposes, data from several other sources are available.

For example, a fire report that includes the area of fire at specified time periods is prepared for every fire of 10 acres or larger burning on lands protected by the Forest Service *(132)*. Similar records are kept by other fire protection agencies. These records provide data on the rate of spread of small fires and the initial stages of larger fires. Data on the spread of large forest fires over longer time periods can be obtained only from the narrative fire reports that are filed in the local offices of the protection agencies concerned.

Occasionally, specific information on the rate of spread of historic forest conflagrations has been published *(11, 56, 97)*. A thorough study of the reports on early fires might be valuable in determining the upper limits of fire spread under the most unfavorable conditions.

Data on wildland fire spread may be available from other countries. Australia, Argentine, Chile, and parts of Africa have areas where the fuels, climate, and fire history are similar to those of parts of the United States. Australia is a particularly promising source of data. It has a serious forest fire problem and a long established fire control and fire research organization. Data from Australian records probably could be applied directly to American conditions.

In general, urban fires are not as well documented for rate of spread as are forest fires. Records of local fire departments usually show the time the fire started, when controlled, and the number of buildings involved, but they include no maps or other indication of the location of the fire front at specified time intervals. Urban fire reports stress cause, equipment used, and monetary damage. Very few fire departments keep their reports on punch cards, and it is therefore time consuming to summarize number of fires and fire characteristics for special studies.

The Fire Record Department of the National Fire Protection Association has a special 1-page Fire Report which it sends to the local fire chief whenever it hears that the city has had a large or unusual fire. Usually these are spreading fires. Space is provided on the form for sketching a fire map and recording weather conditions. Short case histories of most larger fires are published in the N.F.P.A. Quarterly, often with fire maps. How-

[13] Published surface weather data can be found in *Local Climatological Data and Local Climatological Data* (supplement), issued monthly for each reporting station, by U.S. Govt. Printing Office, Wash., D.C. Data contained on the surface weather cards are found in WBAN 1, hourly surface observations. See *Reference Manual 144 WBAN 1 1945*, Weather Bureau Climatological Services Div., National Weather Records Center, Asheville, N.C. Published upper air data are in *Climatological Data—National Summary*, issued monthly by U.S. Govt. Printing Office, Wash., D.C. Upper air data are kept on several card decks. See *Reference Manuals WBAN 535, 542, 544, 545, & 645*, Weather Bureau Climatological Services Div. National Weather Records Center, Asheville, N.C.

ever, only rarely do these accounts contain enough information on time and distances to compute rate of spread. They describe fuels in . . . deta' but usually do not include weather data. After very large conflagrations or very damaging smaller fires, either the N.F.P.A. or the National Board of Fire Underwriters, or sometimes both, will send a special team of investigators to study and prepare a detailed report on the fire. These reports are the best source of time and distance data for computing rates of spread *(9, 71, 83, 87, 99)*. Many excellent reports that contain enough information to compute rate of spread have been written by laymen and are available in libraries *(8, 6?, 86)*.

Although the U.S.S.B.S. reports contain no information on rate of spread, their fire maps showing final area of burnout include data that can be useful for checking model output.

In recent years, many of the largest urban conflagrations in the Western Hemisphere have occurred in Canada *(105)*. Unfortunately, very few published reports are available on these fires.

Urban conflagrations continue to occur in the United States. Many of these could furnish valuable information on rate of spread if an effort were made to obtain these data. Urban fire reports could easily be extended or revised to require noting or mapping the fire perimeter or at least the position of the head at specified times. The N.F.P.A.'s Fire Report could be revised to make more specific requirements for times and distances for fire spread. Weather data during the fire usually is readily available at the local Weather Bureau Office—unless the office burns up as in the Great Chicago Fire and the San Francisco Earthquake Fire.

Data Collected for United Research Services

Wildland Fires

An objective of this project was to provide specific input data for one or more mathematical models of fire spread to be developed by United Research Services, Inc. U.R.S. personnel asked that we provide data on the length of time natural fuels might be expected to burn, weather conditions under which forest fires would be expected to exhibit no significant forward spread, weather conditions under which forest fires might be expected to be extinguished in the absence of effective fire-fighting action, and free rate of spread of large forest fires under known conditions of weather, fuel, and topography.

Burning Times

Burning times were determined by examining the records of experimental test fires in natural fuels where time-histories of temperature or radiation at locations adjacent to the fire were available. Although fires ranged widely in size (from plots 6 by 6 feet to plots 110 by 150 feet) and burned under varying weather conditions, all data seemed consistent in several respects. All plottings of radiation or temperature against time resembled "log normal" distributions; that is, a relatively rapid rise to peak, a slower decline to some value much below peak, but well above ambient, and a very long "tail" before reaching ambient values (fig. 11).

Accordingly, we selected, rather arbitrarily, two burning regimes:

- *Violent burning time* (representing the period of most active flaming): the period when radiation (or temperature) exceeds 50 percent of the maximum value recorded.
- *Residual burning time* (representing the period when glowing combustion is predominant, but flaming is still occurring on at least part of the area): the period after peak when radiation (or temperature) is between 50 percent and 10 percent of the maximum value.

The burning times defined above depend on both weather and fuels, and sufficient data were not available to estimate values for all weather and fuel conditions. As a result, we prepared a table for "average bad" weather conditions and five fuel types (table 1). The weather conditions were: relative humidity 15-25 percent, temperature 80-90°, and wind 5-10 miles per hour. Under drier or windier conditions, violent burning time would be approximately the same as the tabulated values and residual burning time would be shorter. Under damper conditions, all burning times would be materially longer, with a greater percentage increase in violent burning time. Table 1 values

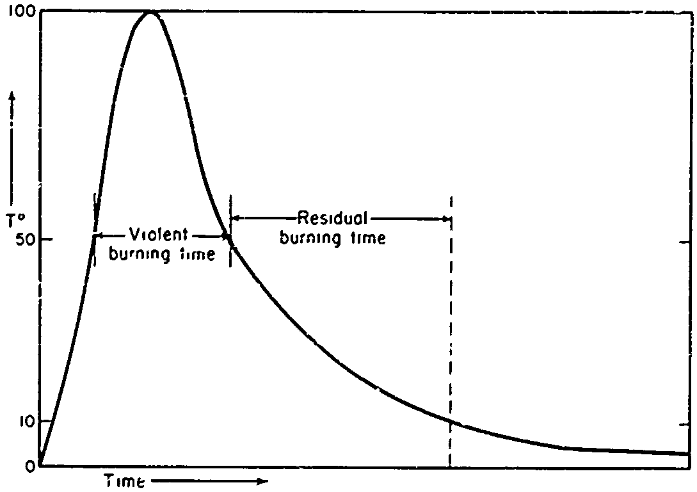

Figure 11.—Distribution of temperature in relation to burning time. T° represents percentage difference between initial temperature and maximum temperature.

were determined from the heat received at a single point adjacent to the fire area.

We were also asked to provide estimates of total burning time (the period during which a large fire might remain stationary yet be capable of resuming active spread if burning conditions changed for the worse). An accurate answer to this question would have to be given in statistical rather than in discrete terms, but such data are not available. Most fires will remain contained if their spread is completely stopped for a few hours. But occasionally a fire will resume spreading after days or weeks of dormancy. Forest fires have even been known to smolder all winter under a blanket of snow and become active the next summer when fuels dry out.

Table 1. Violent and residual burning times, by fuel type

Fuel type	Violent burning		Residual burning	
	Time	Total energy release	Time	Total energy release
	Minutes	*Percent*	*Minutes*	*Percent*
Grass	1½	~90	½	<10
Light brush (12 tons/acre)	2	60	6	40
Medium brush (25 tons/acre)	6	50	24	50
Heavy brush (40 tons/acre)	10	40	70	60
Timber	24	17	157	83

Since there were no data available from which to determine the total burning time, we obtained the opinions of experienced fire control personnel in various parts of the country. The consensus was as follows:

Fuel type:	*Time*
Grass	30 minutes
Light brush	15 hours
Medium brush	36 hours
Heavy brush	72 hours
Timber	7 days

'No Spread' Criteria

To prepare a mathematical model of fire spread in which firefighting effort is assumed to be ineffective, it is necessary to provide "stopping rules," that is, the burning conditions under which fires could be expected to exhibit essentially no outward spread.

Ten of the various fire danger rating systems commonly used in the United States and Canada have as the starting point for the index number system "the weather conditions such that abandoned camp fires or debris burning fires will spread sufficiently to pose a threat requiring fire control action." When we examined the weather and fuel conditions specified for this point in each of the 10 systems, we found them remarkably consistent. Accordingly, we prepared the following list of "no spread" criteria.

Large fires in the following fuel types can be expected to show no measurable spread when the following conditions are met:

All fuels: over 1 inch of snow on the ground at the nearest weather reporting stations.

Grass: relative humidity above 80 percent.

Brush or Hardwoods: 0.1 inch of precipitation or more within the past 7 days *and*—

Wind 0-3 mph; relative humidity 60 percent or higher, or

Wind 4-10 mph; relative humidity 75 percent or higher, or

Wind 11-25 mph; relative humidity 85 percent or higher.

Conifer Timber: (a) 1 day or less since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 50 percent or higher, or

Wind 4-10 mph; relative humidity 75 percent or higher, or

Wind, 11-25 mph; relative humidity 85 percent or higher.

(b) Or, 2-3 days since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 60 percent or higher, or

Wind 4-10 mph; relative humidity 80 percent or higher, or

Wind 11-25 mph; relative humidity 90 percent or higher.

(c) Or, 4-5 days since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 80 percent or higher.

(d) Or, 6-7 days since at least 0.25 inch of precipitation *and*—

Wind 0-3 mph; relative humidity 90 percent or higher.

These criteria were tested against the records of 4,378 forest fires that burned for more than an hour before firefighters arrived and for which adequate spread and weather records were available. Fires were listed as "no spread" if their rate of free spread before the arrival of firefighting forces was 0.4 chains per hour (0.005 mph) or less.

Of the 134 fires that burned under conditions in which no spread would be predicted, 131—97.8 percent—did not spread. Closer examination of the three fires that did spread showed that rain had fallen at one or two but *not* at all of the three nearest weather stations. It is possible that all three failures of prediction were due to showers that wet the weather station, but not the fire area. Thus the criteria selected appear adequate for predicting the weather conditions when fires will not spread significantly.

But 2,537—59.8 percent—of the 4,244 fires that burned when the criteria predicted "will spread" did not spread at a rate of 0.005 mph or faster. Our criteria may have been too stringent, but there are other possible reasons for failure to spread as predicted:

1. Weather measurements were made at 3 p.m., the time of most severe burning conditions; 3 p.m. weather was assigned to the fires regardless of what time of day they were burning. Consequently, many fires were burning under damper and less

Figure 12.—Basic network of weather stations for which fire danger was computed daily during a 10-year period.

windy conditions than is shown by the weather records.

2. Many of the fires may have occurred in isolated patches of fuel where sustained spread was impossible.

3. Weather records were obtained from measuring stations in exposed locations that may have had drier and more windy conditions than those at the site of the fire.

An additional reason for accepting the criteria even though they appear too stringent is that the fires tested were predominantly small. Half of them covered less than 0.1 acre each. On larger fires some part of the fire will always be exposed to the sweep of the wind and the drying effect of the sun, and measurements from an exposed weather station will be more directly applicable.

In connection with another civil defense project *(133)*, daily fire danger was computed for a 10-year period for a basic network of weather stations (fig. 12).

Using data from this study, the average number of days per month when "no spread" conditions can be expected was checked for 18 selected stations (table 2). Since data on snow cover were not available, only the normally snow-free months are included.

'Fire Out' Criteria

We were also asked to decide the conditions under which fires would be extinguished without effective firefighting action. Since we could find no data on large forest fires that wear out by themselves, we were forced to depend on the opinions of experienced fire personnel. The consensus was:

Grass: "No spread" conditions or measurable precipitation at the three nearest weather stations.

Brush or Hardwoods: 0.1 inch of precipitation or more at the three nearest weather stations or "no spread" conditions for three consecutive 12-hour periods.

Conifer Timber: (a) 0.5 inch of precipitation or more at the three nearest weather stations
(b) Or 0.25 to 0.5 inch of precipitation at the three nearest weather stations and "no spead" conditions for the following two 12-hour periods.
(c) Or "no spread" conditions for eight consecutive 12-hour periods and measureable precipitation at the three nearest weather stations during any two 12-hour periods.
(d) Or "no spread" conditions for 14 consecutive 12-hour periods.

Fire Spread Data

The major time and effort on this project was spent in obtaining data on the spread of large fires burning under known conditions of fuel, topography, and weather. This was done by carefully examining 1,621 reports of forest fires 300 acres or larger in size. Spread rates were determined only if:

1. The spread was essentially "free", that is, unaffected by fire control action.
2. Free spread was maintained for 6 hours or longer. (This restriction was necessary because of a universal tendency for forest fires to spread in very rapid "runs" of relatively short duration [see figs. 13 and 14]. Rates of spread measured during such runs are not representative of spread over periods of a day or more.)
3. Linear spread rates could be determined between two known points and two known times.
4. Weather measurements were obtainable either from measurements made at the fire scene or from weather stations located sufficiently near the fire to have representative readings.
5. Fuel types were known.
6. Topographic maps of the fire area were available.

Of the 1,621 fire reports examined, 924 were rejected on the basis of the last three criteria. For

Table 2. Number of 'no spread' days at selected weather stations, by months

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Northern:												
Olympia, Wash.	--	--	24	16	15	16	9	8	15	26	28	31
Boise, Idaho	--	--	--	7	7	3	0	0	1	4	--	--
Casper, Wyoming	--	--	--	9	7	4	2	1	2	4	--	--
Minneapolis, Minn	--	--	--	9	9	9	9	10	9	11	--	--
Grand Rapids, Mich	--	--	--	12	10	9	9	10	8	13	--	--
Albany, N. Y.	--	--	--	13	13	11	10	11	14	15	--	--
Washington, D. C.	--	--	12	10	10	8	9	11	10	12	14	--
Central:												
Oakland, Calif	28	22	13	10	6	3	1	2	2	6	13	22
Cedar City, Utah	--	--	8	3	3	1	1	1	1	3	7	--
Springfield, Mo.	--	--	14	10	10	10	10	7	7	10	12	17
Charleston, W. Va.	--	--	12	12	12	13	12	16	10	14	17	13
Southern:												
Los Angeles, Calif.	16	13	12	13	9	5	1	2	3	6	8	12
Roswell, N. Mexico	4	4	2	1	1	0	1	1	1	3	2	4
San Antonio, Texas	11	10	7	7	8	4	2	2	5	8	10	11
Shreveport, La.	16	13	12	10	10	8	9	7	7	8	12	14
Memphis, Tenn.	21	15	13	9	9	9	10	8	8	9	11	18
Columbia, S. C.	16	13	12	8	7	7	10	11	11	10	11	17
Tallahassee, Fla.	16	12	11	10	11	15	22	19	15	13	14	18

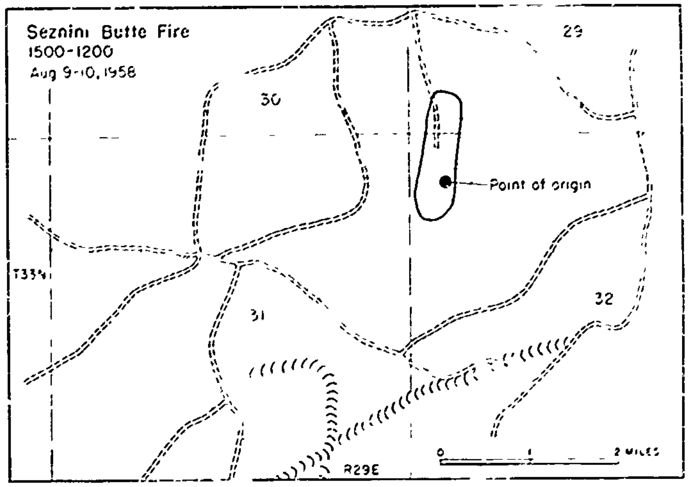

Figure 13.—Extent of fire spread in the Seznini Butte Fire, California, during the first 21 hours.

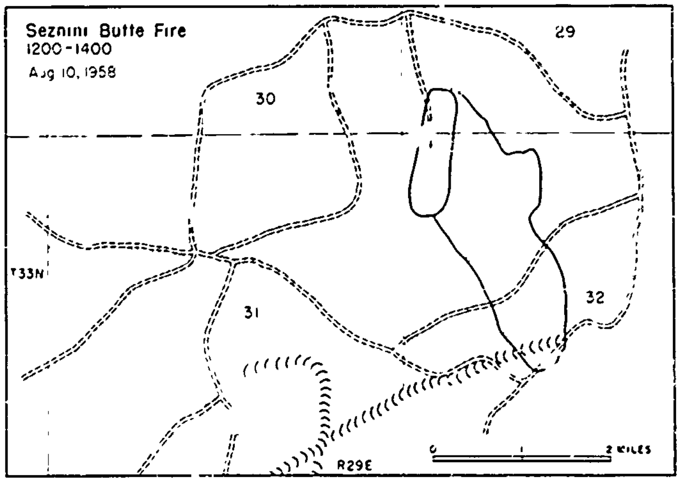

Figure 14.—Extent of fire spread in the Seznini Butte Fire, California, during the next 2 hours.

the remaining 697 fires, we obtained complete narrative reports of the fire behavior and fire control action throughout the history of the fire. A sample report is given as Appendix B. From these reports, we attempted to select areas of fire spread which met the first three criteria. In questionable cases we interviewed, personally or by mail, fire control personnel familiar with the particular fire. We ended up with 533 burning periods on 110 fires from which we were able to obtain 1,614 linear spread rates.

The fires that survived this weeding-out process are not the fastest spreading, nor the most dramatic forest fires on record. On such fires as the Tillamook, which reportedly spread 24 air line miles in one afternoon, we found it impossible to establish accurately known distances and times. In some cases, we obtained known locations and

times, but could not establish the path followed by the fire in arriving at a given point. In many other cases, the period of free fire spread was too short for consideration.

But if these fires are not the fastest of record, neither are they to be considered unusually slow. The 110 fires from which data were obtained burned a total of 1,243,284 acres or 17.7 square miles per fire. Any fire that manages to maintain free spread for 6 hours or longer is probably burning under conditions that are unusually favorable for fire spread. The data included in Appendix D are probably representative of the rate of spread of large forest fires under any but the most extreme burning conditions.

Once a fire had been selected for analysis, the fire perimeter at each known time was drawn on a topographic map. The direction and rate of spread were calculated by determining the direct distance between established related points on successive fire perimeters, measuring the distance of spread, and dividing the distance by the time. A profile of the topography across which the fire spread was then drawn to scale. If the narrative report showed that the fire did not spread in a straight line between the two points, the profile was drawn along the path of the fire, but the direction and rate were still calculated from the shortest distance between the points.

Since one model under consideration by U.R.S. involved prediction of spread rates normal to the fire perimeter, perpendicular lines were also drawn from each perimeter point and the direction and distance to the intersection with the succeeding perimeter were recorded. In cases where the perpendicular line from either perimeter failed to intersect the other perimeter because of peculiarities of shape, neither perpendicular line was recorded.

For example, figure 15 shows the perimeters of two fires; one fire spread from point A to point B in a straight line, A B; the other fire changed directions, following the path A E B. The dashed lines A C and B D were drawn perpendicular to the perimeters at points A and B, respectively. For both fires, the rate of spread was calculated from the straight line A B. The topography was profiled for line A E B on the irregularly spreading fire. Since the perpendicular line B D failed to intersect the inner perimeter on the irregular fire, no perpendicular lines were recorded for this fire.

Information on the fuels along the line of fire spread was obtained either from the narrative report or from interviews with fire control personnel. A fuel type was recorded only if it occupied more than one-fourth of the line along which spread was measured.

Weather information was obtained from 3 p.m. and midnight readings whenever possible. The 3 p.m. weather readings were recorded for all spread periods occurring between 6 a.m. and 6 p.m. Midnight weather readings were recorded for spread periods between 6 p.m. and 6 a.m. Weather readings at 3 p.m. were recorded for all 24-hour spread periods. We chose 3 p.m. because this was closest to the time at which most fire-danger rating systems measure weather for fire planning purposes. It represents the period of the day when burning conditions are most severe and fire spread most rapid. Midnight was selected arbitrarily as being most representative of the night period. Often burning conditions are marginal at night, and the selection of a time closer to minimum tempera-

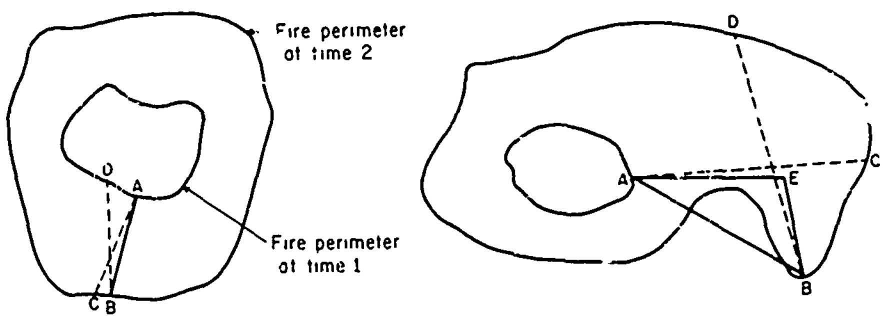

Figure 15.—Geometry of rate of spread calculations between perimeters on two typical fires.

FOREST	FIRE	[illegible]	DATE	TIME FROM	TIME TO	WIND VELOC. (mph)	WIND DIREC-TION	[illegible]	[illegible]	[illegible]	B.[illegible]	FUEL CHARACTERISTIC	SPREAD AND RATE (mph): ORIGIN Az	ORIGIN Rate	END Az	END Rate	MEAN Az	MEAN Rate	ACTUAL Az	ACTUAL Rate
Plumas	Mosquito	1A	81360	0200	1800	7	225	85	14	60	12	Oak brush	—	—	—	—	—	—	024	2450
(Cont.)		1B	81360	0200	1800	7	225	86	14	60	12	Oak brush	—	—	—	—	—	—	022	0635
		1C	81360	0200	1800	7	225	88	13	60	12	Oak brush	—	—	—	—	—	—	056	0350
—		2A	81360	1800	0600	0	—	62	34	65	5	Mixed conifer	304	0117	304	0117	304	0117	304	0117
		2B	81360	1800	0600	0	—	62	34	65	5	Mixed conifer	098	0082	125	0082	111	0082	120	0082
		3A	81460	0600	1800	6	225	83	14	40	18	Mixed conifer	310	0184	310	0184	310	0184	310	0184
		3B	81460	0600	1800	6	225	81	15	40	18	Mixed conifer	—	—	—	—	—	—	208	0287
—	—	4A	81460	1800	0600	5	225	59	37	60	7	Mixed conifer	319	0266	319	0266	319	0266	319	026-
		4B	81460	1800	0600	5	225	59	37	60	7	Mixed conifer	337	0201	329	0250	34-	0416	351	0285
[illegible]	Mt. [illegible]	2A	81360	2400	2400	5	270	69	42	85	5	Red fir	[illegible]	[illegible]	114	0017	115	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	3A	81560	2400	2400	10	225	77	32	55	13	Brush	[illegible]	[illegible]	116	0268	116	[illegible]	081	[illegible]
(Cont.)		4A	81660	2400	2400	8	180	77	20	55	13	Red fir	121	0025	121	0025	121	0025	12	0025
—		5A	81760	2400	2400	7	270	73	21	45	11	Red fir	123	0133	083	0142	103	0138	073	0150
BLM	Murphy	1B	7358	0930	2000	3	338	77	28	55	8	Timber	—	—	—	—	—	—	297	24-0
[illegible]	Dome	1C	7358	0930	2000	3	338	77	28	55	8	Timber	—	—	—	—	—	—	100	1100
		1D	7358	0930	2000	3	338	78	27	55	8	Timber	—	—	—	—	—	—	197	1840
		1E	7358	0930	2000	3	338	79	27	55	8	Timber	—	—	—	—	—	—	12	2260
		1F	7358	0930	2000	3	338	79	27	55	8	Timber	—	—	—	—	—	—	7	2460
Private Land (North Carolina)	Pungo	1A	4859	1100	2400	10	202	80	50	65	5	Brush - timber	—	—	—	—	—	—	032	7240
		2A	4959	0600	1900	17	202	83	67	80	12	Brush - timber	—	—	—	—	—	—	015	8600
Private Land (Wisconsin)	West [illegible]	1E	5159	1230	2030	23	225	89	23	80	39	Jack Pine / Scrub Oak	—	—	—	—	—	—	026	9600
	[illegible]	1F	[illegible]	[illegible]	0900	23	225	89	23	80	39	Jack Pine / Scrub O.	—	—	—	—	—	—	012	4229
BLM [illegible]	Horse [illegible]	4A	8761	0000	2400	5	270	84	21	6	9	Timber	030	0125	344	0113	007	[illegible]	023	[illegible]

Figure 16.—Data as sent to United Research Services, Inc.

tures and maximum humidities might be misleading.

Weather data were obtained from one of three sources. We used weather measurements made at the fire scene when available, and provided that they were taken within 2 hours of the selected times. If weather was not measured at the fire, we used data from the nearest fire danger rating station if available. If fire danger rating stations were not in use, we obtained data from the nearest Weather Bureau reporting station.

Daytime temperatures and humidities were corrected for differences between weather station and fireline elevations by standard methods *(36)*. In nearly all cases the stations were within 1,500 ft., and corrections were minimal. No corrections were made for nighttime weather readings. The burning index as measured by the Wildland Fire Danger Rating System *(127)* was calculated and recorded.

All data and profiles were copied on a standard form as shown in figures 16 and 17 and sent to United Research Service. Appendix D gives a complete listing of all data in more simplified form.

Urban Fires

In general, less is known concerning burning times, "fire out" conditions, and rates of spread for urban fires than for wildland fires.

Burning Times

Burning times were determined by examining the records of experimental test fires in actual buildings of various sizes where time histories of radiation or temperature had been made at locations adjacent to the fire *(3, 50, 51, 52, 65, 106)*.

Although the buildings burned ranged in size from 1-room wooden bungalows to multi-story solid brick or concrete buildings with heavy fuel loading and the weather conditions under which they burned varied, all data seemed consistent in

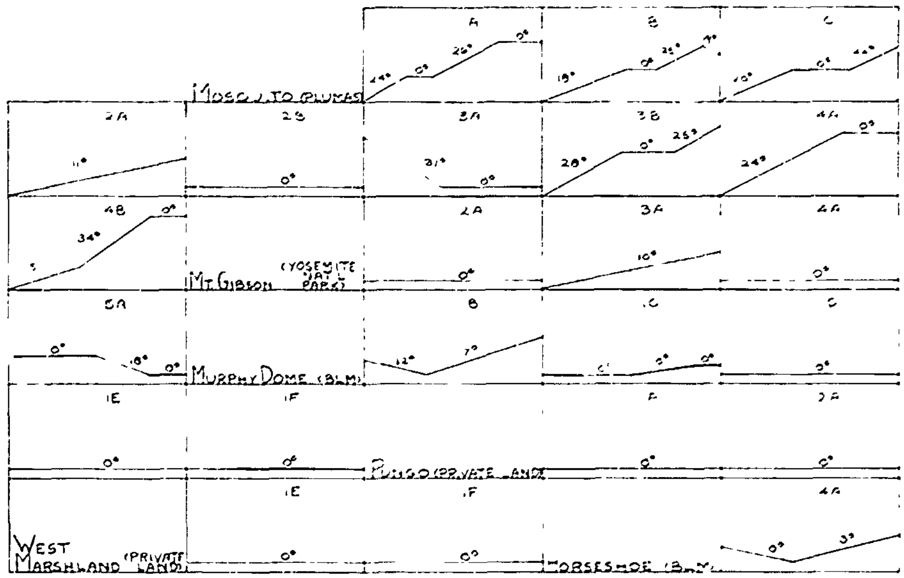

Figure 17.—Profiles as sent to United Research Services, Inc.

several respects. All plottings of radiation or temperature against time also followed a "log-normal" pattern. But the temperature-time curve was displaced to the right of the radiation-time curve for most types of building, particularly those with noncombustible exteriors. Flame, the primary thermal radiator early in a fire, peaks relatively rapidly and then decays rapidly. Most of the radiation from this source emerges through the window and door openings. Temperature, however, remains high after flaming subsides, and high temperatures may persist for long periods. Since radiation from a burning building, particularly from flames, is the principal source of ignition of adjoining buildings, the radiation-time curve was used as a basis for determining burning regimes. Two burning regimes were selected similar to those used for wildland fires:

- *Violent burning time* (representing the period of most active flaming): the period in which radiation exceeds 50 percent of the maximum value recorded. This period coincides fairly well with the "period of maximum flaming" or "second period of burning" described by

Table 3. Violent and residual burning times of urban fuels

Construction type	Violent burning		Residual burning	
	Time	Total energy release	Time	Total energy release
	Minutes	*Percent*	*Minutes*	*Percent*
Light residential	10	80	12	20
Heavy residential	13	70	20	30
Commercial	25	60	60	40
City center and massive manufacturing	55	30	120	70

Thomas *(114)*. This period starts at about the time of flash-over. During this period, most of the combustibles are consumed (114).

- *Residual burning time* (representing the period when glowing combustion is predominant, but flaming is still occurring on at least part of the area): the period after peak when radiation is between 50 percent and 10 percent of the maximum value. In frame residences, this period often starts about the time of structural collapse.

The burning times defined above depend most heavily on fuel loading and to a small extent on weather. Since urban fuels normally are roofed and protected from the extremes of weather, such as rain, snow, and direct solar radiation, only one weather condition is recognized, that is, average weather. Four types were recognized (table 3). The weather conditions were: relative humidity—40-60 percent; temperature—70-80°; and wind—5-10 miles per hour. Under drier or more windy conditions violent burning times would be approximately the same as the tabulated values and residual burning times would be shorter. For less wind all burning times would be materially longer with a greater percentage increase in violent burning time. Accounts of the Hamburg firestorm indicate that the fire had run its course in about 3 hours. Much of the Hamburg area would be equivalent to the Centy Center and Massive Manufacturing fuel type. The largest buildings studied in the St. Lawrence Burns *(106)* were consumed in less than 2 hours.[14] These buildings were equivalent to the Commercial fuel type in the present study.

The values in table 3 were determined from the heat received at a single point adjacent to the fire area. Again, we were asked to provide estimates of total burning time (the period during which a large urban fire might remain stationary yet be capable of resuming active burning if conditions changed for the worse). Most urban fires will remain contained if their spread is completely stopped for a few hours. But occasionally a fire will resume spreading after days or weeks of dormancy. Rekindling fires were a problem for a month after the Hamburg fire of July 1943; some rekindles occurred as late as October of that year *(16)*.

Since few data were available from which to determine the total burning time, we obtained the opinions of experienced city fire department personnel in various part of the United States. The concensus was as follows:

Fuel type:	*Total burning time*
Light residential	36 hours
Heavy residential	72 hours
Commercial	7 days
City center and massive mfg.	2 months

'No Spread' Criteria

The problem of providing stopping rules for city fires is extremely complex. Because buildings are roofed most of the fuel is effectively protected from the gross effects of the weather elements. Fire can spread even when it is raining or snowing. Many such cases have been recorded both during wartime and peacetime. A large increase in relative humidity that might exert a powerful influence on slowing or stopping a wildland fire in a light fuel type probably would have almost no effect on an urban fire. Nevertheless, fires in cities eventually do stop.

Factors that have been mentioned as affecting fire spread and, presumably, stopping are builtupness, spacing between buildings (width of fire break), type of construction, and weather changes. Of the 23 large urban fires studied for this report, 14 were eventually stopped by factors other than direct suppression action or else suppression action played only a small part. In these 14 cases, lack of fuel (low builtupness or wide spacing) was the factor most frequently mentioned as responsible for stopping spread. Change in weather, usually reduction in wind speed or change in direction, was also frequently mentioned.

The four urban fuel types—Light Residential, Heavy Residential, Commercial, and City Center and Massive Manufacturing — reflect different builtupness from low to high in the order given as well as increased amount of fuel loading. In the absence of any better data on which to base stopping criteria for urban fires, for this study the probability-of-spread curves developed by Sanborn *(16)* were suggested with modifications as shown in figure 18. These curves were drawn from a study of fire spread in Hachioji, Japan, following an incendiary attack. Experts believe that Japanese cities are representative of American cities in many respects *(123, 124)*.

The curves show that the probability of fire spreading across a given distance is greater in a fuel type with heavy fire loading (and high built-

[14] Personal correspondence with J. H. McGuire, Division of Building Research, National Research Council, Ottawa, Canada, Sept. 20, 1962

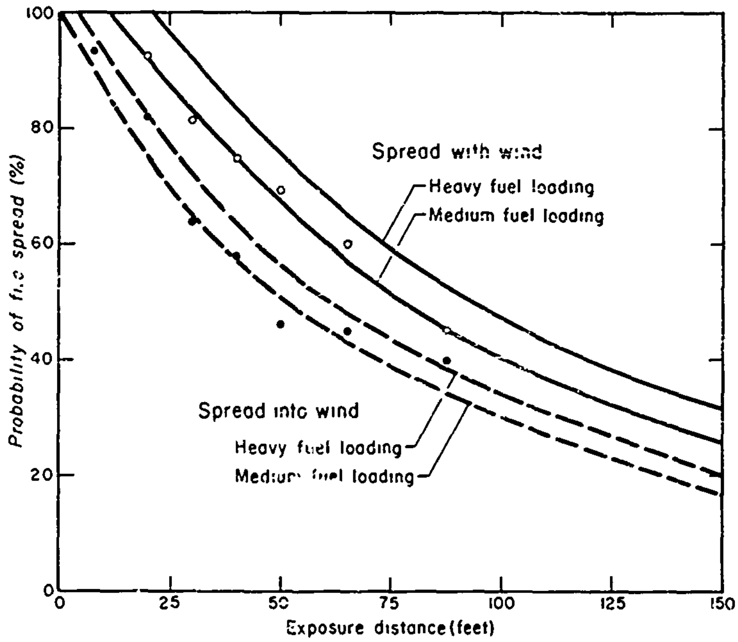

Figure 18.—Probability of urban fire spread across various exposure distances, by type and wind direction.

upness) than in a fuel with light fire loading (low builtupness). Probability of spread is less to windward than it is to leeward in any given fuel type. The curves could be extrapolated toward zero probability of spread. This would give an indication of width of break for stopping or "no spread" in the absence of very long distance spotting.

'Fire Out' Criteria

In addition to determining the fuel and weather conditions under which fires might be expected to remain stationary, we were asked to decide the conditions under which fires would be extinguished without effective firefighting action. The only data available on fires that essentially went out by themselves are the accounts of certain incendiary raids on Japan and Germany during World War II *(16, 17, 136, 137, 138, 139)*. The following "fire out" criteria are based on these data and the opinions of experienced fire chiefs.

- Light residential: 1.0 inch of precipitation at the Weather Bureau Station and "no spread" conditions for 36 consecutive hours or "no spread" conditions for 48 consecutive hours.
- Heavy Residential: 1.5 inches of precipitation at the city Weather Bureau Station and "no spread" conditions for 72 consecutive hours or "no spread" conditions for 100 consecutive hours.
- Commercial: 2.0 inches of precipitation at the city Weather Bureau Station and "no spread" conditions for 7 consecutive days or "no spread" conditions for 10 consecutive days.
- City Center or Massive Manufacturing: 2.0 inches of precipitation at the city Weather Bureau Station and "no spread" conditions for 2 consecutive months or "no spread" conditions for 3 consecutive months.

Fire Spread Data

To obtain data on the spread of large city fires burning under known conditions of fuel, topography, and weather, we examined 254 [illegible] or case histories on spreading fires involving one or more city blocks. Spread rates were determined only if:

1. The spread was essentially "free," that is, unaffected by fire control action.

2. Linear spread rates could be determined between two known points and two known times.

3 Weather measurements were obtainable either from measurements made at the fire scene or from weather stations located sufficiently near the fire to have representative readings. Usually there were Weather Bureau offices located in the downtown section of the city.

4. Building (fuel) types were known.

5. Topographic maps or accurate descriptions of topography of the fire area were available.

Of the 254 case histories examined, 195 were rejected on the basis of the first three criteria. In questionable cases we interviewed, personally or by mail, fire control personnel familiar with the particular fire. Whenever possible, we tried to obtain more than one account of the same fire as a check. As many as four different accounts of a single fire were found. We ended up with 73 linear rates of spread on 23 fires.

The fires that survived this weeding out process include most of the largest and fastest spreading city fires of record in the United States. Only one Canadian city fire, Ottawa-Hull, 1900 *(105)*, is included, although some of the largest city fires in the Western Hemisphere in recent years have been in Canada. Time and distance data from which rates of spread could be computed and weather records were not available for most of these fires

By no means did all of these large fires burn under unusually severe burning conditions. There were cases of snow on the ground, low wind speed, and buildings wet from recent rains. The 23 fires from which data were obtained burned a total of about 12,000 acres, or 20 square miles, and more than 100,000 buildings. The data included in this report are probably representative of the rate of spread of large urban fires under a complete range of burning conditions. Fires from almost every section of the United States are included.

Once a fire had been selected for analysis, locations of the fire front and times extracted from the narrative were plotted on the fire map. Usually a city street map showing the final fire perimeter was included in one or more of the case histories. Occasionally the map scale was not given and had to be obtained by writing the city engineer. All but a few fires were in cities on relatively level sites. Whenever topography was a factor in fire spread, topographic maps were obtained and slopes determined.

Information on the fuels along the line of spread was obtained either from the narrative report, photographs in the case history, or from interviews with local fire chiefs or engineering departments. A fuel type was recorded only if it occupied more than one-fourth of the line along which spread was measured.

Weather information was recorded for the start of the particular run or period of spread or for a time close thereto.

The direction and rate of spread was calculated by determining the direct distance between established points at the midpoint of the fire's head, measuring the distance of spread, and dividing the distance by the time. Many of the city fires studied lasted only a few hours and position of the front was noted at random times, or when a particularly big or historic building started to burn. Consequently, it was not possible to list rates of spread for set periods such as the 12 hour burning period used for recording rate of spread on wildland fires. Rates of spread for two or more consecutive shorter runs can be averaged, however. Sometimes averages for longer periods are more representative because of the tendency of fires to spread in spurts with relative lulls in between. Urban fires appear to spread about equally well night and day So the day-night distinction used for analyzing wildland fire spread is not so important for city fires.

All data were copied on a standard form as shown in Appendix E. A complete listing of all data is presented.

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Appendix A

Estimators of Fire Modeling Parameters Obtainable from Aerial Photographs[15]

The success of a predictive fire model depends on the adequacy of the selected parameters for predicting fire spread in a given set of circumstances and on the ability to assemble, on a massive scale, data concerning the parameters. If either condition is unsatisfied, use of the model is impractical. Collecting all sample data on the ground over the entire United States would be prohibitively costly, but aerial photogrammetry and photo interpretation have proved particularly reliable aids in collecting geodetic, topographic, and vegetative data over large areas with maximum speed and minimum cost.

This report discusses the various parameters which can be feasibly obtained from aerial photographs consistently and accurately for use in predictive fire modeling The present availability of sample data is also discussed. Further, we wish to know the kinds of new data which can be obtained by trained personnel with available equipment, and the kinds of data which could feasibly be collected with available or prospective automated equipment.

Four main factors to be considered in defining fire spread parameters are: (a) geographical location, (b) topography, (c) fuels, and (d) weather We will consider only the first three; each includes several parameters for which unbiased estimators are desired as well as their variances.

Parameters Obtainable from Aerial Photographs

Geographical Location

X and Y coordinates of any point on the land area, standardized to a map projection, can be obtained to a high degree of accuracy when photogrammetric control is maintained with plotting instruments. The accuracy of location depends on the precision of the camera and plotting systems, the skill of those using the equipment, the scale of photography, the amount of tip and tilt at the time of exposure, the type of control used, and the specifications of the photographic materials used. The range of average error would run from about 10 feet to 300 feet, depending on the combination of the above factors present on a given project.

If photogrammetric control is not used but good maps are available, the coordinate position of a spot on the ground can usually be estimated within one-fourth mile of its true plan position at the photo center and within one-half mile at the photo edges on 1/20,000 scale photographs taken through an 8¼-inch focal length lens.

Topography

Three main topographic parameters concerning a point on the land surface can be consistently determined from controlled aerial photographs: elevation, steepness of slope, and aspect. The obtainable limits of error in absolute elevation are affected more by the type of control used than are horizontal measurements. However, the average error can be maintained somewhere between 5 feet and 100 feet, depending on the project specifications.

The accuracy of slope determination is, of course, dependent on the accuracy of the relative horizontal and vertical differential between the reference points used in determining the slope. In general, we can obtain good slope estimates if we can see the ground surface at both ends of the reference line.

Aspect (direction of slope) can be accurately determined within a wide range of project control specifications.

If no photogrammetric control is used, the elevation of a point can best be determined from topographic maps. The limits of error will depend on the accuracy of the map itself and on the horizontal accuracy maintained in point location. In this situation, the topographic parameters of elevation, slope, and aspect should probably be estimated strictly from maps without regard to the image position on a photograph.

Fuels

The fuel type classifications desired for predictive fire modeling which can be obtained from aerial photographs are best determined if one begins with the following broad groups of classification: (a) urban areas, (b) agricultural areas, (c) wildland areas, and (d) water areas.

Urban areas.—These can easily be subdivided into industrial, commercial, and residential groups. Within each group, photo interpreters can easily distinguish buildings, streets, parking lots, vacant lots, lawns, shrubs, trees, swimming pools, canals, harbors and other features. The parameters which can be measured for each item, where applicable, are length, width, height, and the distance between items. From these measurements, other indexing parameters, such as size, distribution, and density, can be determined.

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[15] Prepared by Philip G. Langley, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, for Final Report to Office of Civil Defense U.S. Department of Defense, Contract OCD-OS-62-131.

Vegetation characteristics within urban areas will vary according to the season of the year because of winter defoliation of trees and shrubs and ot! r physiological changes. Therefore, summer and winter data c.. .ie area of ground covered by foliage would be desirable.

Agricultural areas.—These can be subdivided into fallow, orchards, vineyards, row crops, close-grown crops, and pasture if photo scales of about 1:5,000 are used. On smaller scale photography, fallow ground and orchards will each be discernible; vineyards will merge with tall row crops; small row crops, close-grown crops, and pasture will merge into a single discernible group. Row crops include corn, milo maize, beans, peas, cabbage, tomatoes, and carrots. Close-grown crops include rice, wheat, oats, barley, rye, alfalfa, and hay

Parameters which can be measured in agricultural areas are length and width of fields, roads, buildings, and the distance between these items. Heights of trees (orchards) and their crown width can also be measured. The heights of taller row crops can be measured on aerial photos if good plotting instruments are used, provided the height of the camera station is no greater than approximately 6,000 feet (independent of photo scale). However, it would probably be more feasible to dichotomize these items into "tall" or "short" groups. Other indexing parameters such as vegetative density and crop spacing can be determined with varying degree of reliability. Special filtering can be used at the time of photography to maximize the tone contrast between crop types if the spectral characteristics of each is known (Colwell 1956) This information can be read and interpreted electronically (Langley 1961).

Crops on agricultural land usually vary a great deal owing to the seasonal nature of many agricultural crops and to the practice of crop rotation on specific areas. Consequently, any information concerning crop parameters for a specific time period will be quickly outdated.

Wildland areas.—These can be classified as bare ground, grass, brush, or trees fairly consistently on existing photographs. Hardwood trees taller than 40 feet can usually be distinguished from conifers of the same height or taller by using photographs from 1:18,000 scale or larger with good image resolution. The interpreter's ability to distinguish between hardwoods and conifers is also affected by the season of the year and the film filter combination used. It is very difficult to consistently separate hardwoods from conifers of a height less than 40 feet unless photographs taken under rigid specifications are used.

The accuracy of height measurements on vegetation also depends on the photo specifications. Generally, height measurements are less reliable when made in heavily forested areas than when made in open forest stands or in urban or agricultural areas because the foliage in tree crowns, deep shadows, and understory vegetation obscure the ground surface. Height measurements can generally be maintained to within about 40 feet in dense, old-growth redwood or Douglas-fir stands and to within about 20 feet ... other forest types. It is not practical to measure the height of vegetation less than about 20 feet tall on available photographs taken from a height of 15,000 or more feet above the ground.

The percent of crown closure on a small area (1 acre) around a ground point can be ocularly estimated within about 10 percent. Crown diameters of prominent trees can be measured to close tolerances on photographs of any workable scale if the image resolution is good. Other indexing parameters concerning size, spacing, or distribution can be formulated from height, crown closure, crown diameter, a·· the distance between trees, stands, or other unit designations

Parameters concerning vegetation in wildland areas are, of course, subject to seasonal variations, particularly in deciduous forest

Water areas.—These can be distinguished on nearly all photography taken under a variety of conditions.

Methods of Data Collection

Method Versus Estimator Bias

To determine the usefulness of existing data and the optimum method of collecting new data for use in predictive fire modeling, some consideration should be given to the possible bias inherent in the estimators.

Measurements taken from uncontrolled photographs result in errors of estimate owing to relief displacement and distortion in the plane of the stereo model. These errors may or may not result in bias when estimating the desired parameters for fire modeling For instance, estimates of land area vary inversely with the flight height above the terrain. The estimates of land areas which lie above and below the datum plane of a photo project can average out if the distribution of the samples happens to balance around the mean datum.

Other errors in area estimates can be caused by the varying tilt of the ground surface with respect to the position of the camera station. These errors can result in considerable bias (100 percent) if the flight lines happen to parallel high ridges or canyons. Moessner (1957) reported that no significant bias occurred in area estimates with dot sampling from uncontrolled aerial photographs in the Rocky Mountain, whereas Wilson (1949) reported earlier that bias does show up when making dot count estimates for "small" areas.

Bias in height measurements, when using uncontrolled photographs, can also be caused by varying flight above the terrain. This bias can amount to as much as 30 percent between the extreme flight height difference under normal photographic conditions.

Therefore, one must weigh the possible effects of random error in measurement encountered when using uncontrolled photography against those encountered when using controlled photography as well as the relative cost of each method.

Method Versus Variance

The usefulness of the estimated variance around each parametric mean will depend on the data mode. For example, it is rarely possible to calculate a valid estimate of the variance from any data extracted from a forest type map because no information is collected on the "within group" variation, but only on the "between group" variation It can be shown that the "within group" variation of vegetative type size, and density as shown

on a type map, is of sizable magnitude and is often as great as the "between group" variation.

As another example, a true picture of the terrain form is not realized simply from the variance around the mean elevation. The variance around the mean elevation in plateau country can be exactly the same as the variance in very broken country with many changes in slope. Therefore, some other parameter must be used, such as the difference in elevation between adjacent points in a systematic grid, or the distance between slope changes and the steepness of the intervening slope as measured from a line transect.

Availability of Existing Data

An extensive study would be required to learn exactly the kinds and amounts of useful data available for predictive fire modeling. My personal knowledge of data concerning the types, amounts, and distribution of fuels in urban or agricultural areas is limited. But much relative information has been collected in wildland areas for forest, range, and soil surveys

Some of the existing data concerning vegetative fuel types in wildland areas of California exist in the form of forest type maps or soil-vegetation maps. Area estimates made from these maps contain little bias owing to relief displacement because the maps were generally compiled through plotting instruments of some type. These maps usually contain no information concerning terrain characteristics, but such information can be obtained from topographic maps and tied into the type maps. The maps usually contain information on the vegetative density of an area, but often have no direct figures on vegetative heights. Some type maps made in the Pacific Northwest, however, do contain height and density information. The forest survey maps and the soil-vegetation maps made in California before 1961 contain age-density classifications from which height can be approximated.

In addition to the survey type maps, the Forest Service has made similar maps for management purposes on the National Forests. The extent of this mapping work would have to be determined by further inquiry.

Most, if not all, of the large area forest surveys have now departed from type mapping as a means of data collection from aerial photographs. Photo-point sampling of some form is now used to collect this data. However, the kinds of data collected in different regions of the United States differ considerably.

The photo classification system presently used in California collects data on general location, productivity class (commercial forest, noncommercial forest, or nonforest), major forest type, timber size class, and volume class. The survey has collected photo information on elevation, aspect, and topographic situation only in Mendocino and western Siskiyou counties. Some of the other regions collect similar data: some only separate out the area of commercial forest land. All the photo-point information presently collected is gathered without photogrammetric control, and the information cannot be directly correlated to topographic information by point-to-point correspondence without a considerable amount of control work.

The intensity of photo-point sampling in California varies from about one point per 150 acres to one point per 320 acres. The sampling intensity in other regions goes as high as one point per 75 acres.

Collection of New Data

The methods used for collecting new data concerning the estimators of the selected parameters will depend on the short- and long-term requirements of intensity, accuracy, timeliness, and cost

Use of uncontrolled photography.—If only a single reference value along with an estimated variance is required for each parameter within a 5½-mile square area, photopoint sampling using uncontrolled photographs would probably be speedier than any other system, provided few measurements are required. However, it should be recognized that data of unknown accuracy and statistical validity will result, regardless of whether or not special purpose photography is used. Also, this method of approach would nearly preclude the possibility of later intensification of the data for use in instantaneous fire-spread predictions on going fires when using electronic computers.

Use of controlled photography.—Controlled photography offers many technical advantages, but may increase time and cost of data collection. However, I believe that the advantages of using controlled photography can be gained without substantially increasing the time or long-term cost if a reasonable complement of equipment is assembled for use with special-purpose photography. If the U. S. Air Force could be persuaded to furnish civil defense offices with high altitude precision photography, taken to specifications, controlled data, with known limits of accuracy and statistical validity, could be obtained from existing plotting and data-recording equipment costing between $10,000 and $20,000. The Air Force RC-130A aircraft equipped with the HYRAN mapping system (Walls 1960) or similar systems are reported to be fully capable of producing radar-controlled precision photography from which the information could be taken. Aerial photographs of high resolution in 9- by 9-inch format and taken at a scale of 1:60,000 through a 6-inch focal length lens would cover approximately 22 square miles per stereo model. From these photos, an interpreter could measure well defined horizontal lines, such as street widths, to an approximate accuracy of plus or minus 5 feet. Vertical measurements of well defined objects could be obtained to plus or minus 15 feet under optimum conditions. Over-all geodetic control of ground points could be maintained to an average error of plus or minus 60 feet horizontally and plus or minus 20 feet vertically if necessary, and some relaxation of these requirements would allow considerable increase in speed.

Virtually all parameters mentioned at the beginning of this report could be collected and placed on EDP magnetic tapes for use in predictive fire modeling with the equipment complement referred to above. If data were collected with sufficient intensity, they could be effectively used in terrain analysis problems and in research on behavior of going fires

Prospective Use of Automated PI Equipment

Much interest has been generated in recent years concerning the possibilities for obtaining PI information from aerial photographs automatically. Some pieces of automation equipment are now available for special use and more will be available in the near future. However, to use this equipment effectively for predictive fire modeling, some modifications would be needed to assemble an integrated interpretation system which would record all pertinent data and convert to an optimum form for processing. These modifications will require imagination, but much progress has already been made in their development.

Recently developed electronic scanning instruments will record line profiles and compile topographic maps automatically. Both the Benson-Lehner "stereomat" system and the Ramo-Woolridge stereo mapping system have been developed to a high degree. A third digital automatic map-compilation system now under development appears to offer much promise toward the solution of automatic interpretation problems and EDP.

Researchers have demonstrated the usefulness of taking photographs through selected filters to detect crop diseases (Colwell 1956) and to differentiate between tree species (Colwell 1960, Olson 1961). At least one researcher has made preliminary statistical analyses of reflectance data of field crops and has demonstrated that a number of crop types and other objects can be "read" and identified electronically from special-purpose photography and that the probability of detection can be determined (Langley 1961, 1962). Others have studied methods of terrain recognition through multiband sensing techniques using radar magnetometers and infrared (Frost 1960; Hoffman 1960, Newbry 1960; Scheps 1960; Olson 1960; Lyytikainen 1960). A relatively new and promising technique using digitized contrast frequencies was explored by Rosenfeld (1962) for the purpose of developing a method of automatic land-use classification from aerial photographs.

Even though much of this equipment is still in the developmental stage, enough progress has been made to indicate that the application of automated instruments to photo interpretation problems is definitely on the horizon. Consequently, in selecting a method of data collection used in the beginning for predictive fire modeling, a method that will yield data compatible with data obtained from automated equipment should be preferred. I can visualize how, by using an integrated complex of interpretation instruments, it will be possible to locate, identify, and measure nearly all required parameters and record the results in digitized form—all automatically. Interrogation of the data can then be made for many purposes depending on the particular computer model used at a given time.

Summary

Aerial photographs are useful for gathering geodetic, topographic, and vegetative data because they permit coverage of large areas of land much more rapidly than ground methods. Data concerning the defined parameters to be extracted from photographs should be restricted to that which can be measured with instruments or directly estimated from visible features. Subjective estimates should be avoided. The reliability of the data depends on the photo specifications and on the interpretation equipment used. Geodetic control can be maintained in the X, Y, and Z directions with plotting instruments, and the dimensions of visible features in three dimensions can be similarly obtained. Information on land use and vegetative types can be effectively measured, particularly if the photo specifications are prescribed to fit the job. Seasonal variations in vegetative manifestations should be taken into account.

The validity of the variances concerning the defined parameters depends on the method of data collection. Some methods of collection, as from type maps, will ignore some components of variance, while others will be ineffective for use in predictive fire modeling. The form of the data should be consistent with that which may be obtained with automated PI procedures so that the inevitable change-over will take place smoothly and efficiently. A digital system, based on photo-point sampling, will probably best lend itself to later intensification and to high-speed data collection, processing, and retrieval. Minimum photogrammetric control or no control can be tolerated if it is only necessary to collect information concerning the parametric means on areas approximately 5½ miles square.

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Appendix B

Example of a Wildland Fire Case History

(Note: This is an abridgement of a typical narrative fire report. In determining rates of spread from such a report, the fire action was plotted on large scale contour maps and the weather data were supplemented from adjacent Fire Danger Rating and Weather Bureau stations.)

The Lyons Peak Fire of Sept. 30 – Oct. 4, 1945

Control Action—September 30, 1945.

8:00 a.m. Lyons Peak weather: T° 71—Humidity 19—Wind ESE 8.

8:22 a.m. Fire start.

8:24 a.m. Fire reported on Lyons Valley Road ¼ mile west of Lyons Valley Suppression Station by Lyons Peak Lookout.

8:25 a.m. Called California Division of Forestry.

8:28 a.m. Lyons Peak reports smoke picking up.

8:30 a.m. Alpine Tank Truck crew was dispatched to fire. Suppression foreman, tank truck operator, and three crew men. Lyons reported fire going good.

8:33 a.m. F. C. A. Davis. Descanso Tank Truck crew, consisting of foreman and four men, were dispatched to fire.

9:07 a.m. La Mesa Tanker dispatched.

9:24 a.m. Davis arrived at fire (51 minutes travel). Fire approximately 5 acres, burning up hill to north and east. On arrival at fire, Davis found five local men standing on road watching fire burn; these men had no tools, Davis equipped them with all available tools from his pick-up and placed them along road to keep fire from spotting over road. After sizing up the fire, Davis placed an order for two tractors and I.R.C. crew (16 men Laguna).

9:31 a.m. Descanso Tanker arrived via Japatul Barrat, Davis instructed Foreman Brown to work east line of fire north from road, using water as far as possible, then continue along line with hand tools. This line constructed about 500 feet, when fire spotted over road. Foreman Brown pulled his crew off line to try and pick up spot-over. At this stage the fire seemed to blow up all over and was too hot to work with tools.

9:40 a.m. Alpine Tanker arrived via Sweetwater and pulled off road in front of fire; running out two hose lines, crew succeeded in knocking down north flank of slop-over. At the same time the C.D.F. Tanker from La Mesa arrived and started working south line from road out. Fire was traveling too fast for this crew to work flank to head off fire. The Descanso Tanker ran out of water and had gone to Lyons Valley Station for refill. This crew working hand line up south flank, aided by C.D.F. Tanker crew.

9:50 a.m. Second C.D.F. Tanker arrived from La Mesa.

10:14 a.m. Davis sized the situation up and decided the one remaining try was to fire the road from Lyons Valley Road to switch-back one-third way up Lyons Peak road. Sent the C.D.F. Tanker around back of ranch north of road to fire from open field south and tie into Lyons Valley road, near station. Davis started Foreman Austin with Alpine Tanker and crew, firing Lyons Peak road from County road up hill. Davis took Descanso Tanker, crew, and the locals to switchback and began firing down hill to meet Austin. His plan was to control the head of the fire south of the County road and the past line on the north of road.

10:14 a.m. Davis reached the switchback in time to check the head of the fire. As the two crews fired towards each other, the fire continued to gain headway and backfire had to be carried too fast to give adequate patrol behind Descanso Tanker. The fire spotted over road—all but two men were started to work picking up this slop-over, while tanker and two men carried backfire on down road to tie in with Austin. As soon as the backfiring tied in both tanker crews and pickups were left to tie in slop-over, which by this time was approximately 3 acres burning in heavy brush in steep rugged country.

10.52 a.m. Cleveland team dispatched including 60 Firefly.

12:00 m. Lyons Peak weather: T° 84—Humidity 10—Wind NW 4.

12:10 p.m. Davis left Foreman Austin in charge of the above line and proceeded to line north of county road. Upon arrival at the county road he contacted State Ranger Miller. Miller informed Davis he had just sent the Sampo tanker crew of four men around to aid the La Mesa Tanker crew in carrying a line south from open field along west side of fire which was cool enough to work with hand tools. Also, the State's Woodson crew was coming in as well as the I.R.C. crew and another larger tanker.

2:15 p.m. State Ranger E. M. Miller, J Ewing, and Davis met at the Lyons Valley State Guard Station. Miller asked that the U S Forest Service take charge of the fire and use Forest Service forces to fight it since most of his forces were already on other state fires. Ewing agreed to take the fire over and use Forest Service force since the fire was a definite threat to the National Forest.

Plan of Action—Day Shift—September 30, 1945:

2:15 p.m. Forces on the fire:

- 2 Forest Service tank trucks and crews, 11 men.
- 2 State Division of Forestry tank trucks and crews, 8 men.
- 8 Pick-up Fire Fighters

Forces ordered to arrive within a short time.

- 1 State Division of Forestry Tanker
- 16 Men—County Prison crew
- 15 Men—Woodson crew, State Division of Forestry

Also several Forest Service and State Guards.

This was about all of the manpower and equipment that could be expected to arrive on the fire before 6 p m. The plan for the remainder of the afternoon was: Continue to use two Forest Service tankers and crews with 8-man pick-up crew on road from Lyons Valley to Lyons Peak. Try to keep fire from crossing the road to the east side.

Two State Division of Forestry tankers and crews to continue to north on east side of fire from Lyons Valley road, cut off head of fire if possible.

To use two crews coming in on west side of fire, one crew to work southeast from Lyons Valley Road and cold trail line, the other crew to work north from Lyons Valley Road and cold trail line.

Action and Accomplishment: All crews worked as planned. None of the crews was able to flank or pinch in the head of the fire.

Plan of Action–Night Shift—September 30, 1945:

4 p m. Status of fire

Size: 291 acres

Fire line controlled 1.25 miles

Fire line uncontrolled: 2.6 miles

Weather: See Weather record attached.

Fire still spreading rapidly to both north and south, running up slope on both heads.

Manpower requested for night shift

- 50 Firefly from San Diego
- 200 Military, Navy, from San Diego
- 2 tractors, one from Oak Grove, one from Descanso
- 3 tankers in addition to four already on fire

Forest Service and State Division of Forestry overhead was ordered to handle above manpower.

4 p.m. Lyons Peak weather: T 70 — Humidity 22 — Wind WNW 19

Organization and Strategy: Fire would probably go to ridges both to north and south. Was lying down some on all flanks and could be worked by hand crews.

Strategy was to control fire with night crews. The fire had been scouted by Davis, Miller, and Ewing and it was believed that sufficient equipment and manpower were available and ordered to accomplish control.

The Cleveland fire team took charge of the fires. Fire camp and headquarters were set up at Lyons Valley State Suppression Station.

Division I. 35 Firefly Troops to go out Lyons Peak road to head of fire, divide crew, and work two directions, cold trail line

Division II, Sector A. 100 to start work from Lyons Valley Road and cold trail fire line North to top of ridge or tie in with Sec. 8.

Section B. To go out through burn (old road and trail) from Fire Camp to top of ridge and work north, cold trail northeast to tie in with tractor working from skyline truck trail to meet them. One tractor to go out skyline truck trail, cut line from road to fire line and cold trail line southwest to meet hand crews. One tractor to go into west end of Division 2, Sector B, and work all line possible.

Division III. To use tanker crews and go out skyline truck trail to west end of fire, to back fire from that point to Lyons Valley road. South line of fire north of Lyons Valley road backing in to open fields.

Action and Accomplishment: Division 1, Sector A. Firefly crew 20 men cold-trailed fire line down ridge west from Lyons Peak. Area very rough and steep. Cold trail not completed All line hot-spotted through entire sector

Sector B. Firefly Crew men cold-trailed fire line to bluffs north of Lyons Peak, too rough and steep to work. Went around bluff area and worked line from where day crew left cold trail in to north end of bluff area, hot-spotting only

Division II, Sector A Completed cold trail over entire sector.

Sector B. Completed cold trail over entire sector. Tractor worked about 0.4 mile of this line. Also constructed secondary line 0.3 mile in around spot fire on north side of road in Division 3 Too rocky to work on fire line at night. Tractor did not arrive on fire line until 3:15 a m October 1, due to breakdown of contract truck hired to transport it from Descanso

Forest Service Tractor from Oak Grove did not arrive on fire until 6 a m., owing to breakdown of Forest Service transport truck.

Division III. Line was completed, backfired as planned along roads. Some mop-up left to do on entire line. No cold trail around spot fire on north side of skyline truck trail Secondary tractor line around it only.

Slopover Plan was to burn out the slopover. In the morning, Rockwell, in charge, with three tankers and crews and one cat tried burning; unsuccessful and so decided to let fire burn out.

Rockwell and Ranger Miller optimistic about this piece. Rockwell did not want to use tanker or cold trail. He wanted to let it burn out. His objective was to get this area burned out clean. Forty-five minutes later (10:45 a.m.) fire broke.

Plan of Action—Day Shift—October 1, 1945:

12:01 a.m., October 1: Fire scouted by Ewing, Davis, Sindel. Fire had stopped running.

Size: 760 acres
Fire line controlled: 8.9 miles
Fire line uncontrolled: .4 mile
Fire line to be mopped up: 9.3 miles

Action and Accomplishment: Division I. Men assigned to line and placed as planned. Line was completed around entire Division. Some mop-up still needed in vicinity of bluffs north of Lyons Peak. Three Navy tractors arrived on fire about 6 a.m. Due to condition of lines in bluffs north of Lyons Peak, these tractors were dispatched to construct a secondary fire line from the Lyons Valley Road ½ mile east of the Fire Camp To work south to main ridge and as near to Lyons Peak as possible. This line was completed to within 0 3 mile of Lyons Peak. Cats were then pulled back to Lyons Valley Fire Camp.

Division II. Men were assigned to the division as planned, except 12 who were pulled back on the slopover on Div. III, because 50 men ordered from the 11th Naval District had not arrived on the fire. This entire line held and was reported completed at 10 a.m. and before the break on Div. III.

Division III. Three hundred men ordered from the 11th Naval District. Arrivals were assigned and dispatched to other Divisions first since Div. III was more accessible. This left Div. III without any hand labor. As soon as this became apparent, about 9 a.m., 12 men were shifted from Division II to the slopover on Division III for the backfire job. Men were shifted all along the line on Division II to fill in where men were taken for Division III.

One additional tank truck and crew were assigned.

Division Boss Rockwell decided not to backfire the slopover but to let it burn out

10 a.m. Lyons Peak weather: T° 75 — Humidity 12 — Wind ESE 14

10 a.m. Gowen, Ewing, and Miller had gone over slopover line and decided it should be mopped-up Two tractors, two tankers and 12 men were assigned to concentrate on this job.

10·45 a.m. Fire jumped the line on the west end of the slopover. Crews on hand at the slopover were unable to control the spots. Fire made a 3-mile run west by 2 p.m and 5½ miles by 6 p m

One tractor was started to work east line of break and accomplished about ¾ mile of cold trail. All men on Divisions I II, III remained on their respective lines and held them except Sector B, Division II. All available overhead and tanker equipment were dispatched to the skyline road to try to hold fire on north side of road. This attempt failed.

The next attempt was made to hold the head of the fire east of Lawson Valley road and the Lyons Valley road in the vicinity of the Junction of these two roads and the skyline truck trail. This attempt also failed.

Plan of Action—Night Shift—October 1, 1945:

4 p.m. Status of fire:

Size: 5,600 acres
Fire line controlled: 7.4 miles. Died out in old burn 2.2 miles.
Fire line uncontrolled: 11.2 miles.
Fire spreading on all uncontrolled sections of fire line.

4 p.m. Lyons Peak weather: T° 76 — Humidity 13 — Wind ESE 19

Fire was still running on all lines that had not been worked. Uncontrolled line was 11 2 miles (map miles) which would mean 15 to 17 ground miles. Approximately 4.6 (map miles) or 7 ground miles could probably be worked with tractors. Two miles could be backfired from the Lyons Valley Road with tank truck crews This left 7 to 8 miles to be cold-trailed by hand.

Five hundred men were needed and possibly could control the line. However, overhead was available for only 230 men. Strategy was planned to control the fire from the original lines to the west as far as possible with crews available.

Special effort to be made to control Divisions II and IV Division III to be controlled from east to west as far as possible, and Division I to be patrolled and held.

Action and Accomplishment: Northern fire team arrived and took charge of fire at 9:00 p.m. Division I line held with no breaks through night shift. Division II, Sector A, tractor worked secondary line into fire from Lawson Valley Road, worked fire line east as far as possible. Tractor then went back to secondary line and worked fire line west into Canyon and could go no further. Twenty-five men worked from end of tractor line on SE end of Division II, to end of tractor line at NW end of Sector. Line was hot spotted and dangerous spots cold-trailed. (All line on Division II, Sector A held until flanked from the west on afternoon of October 2)

Division II, Sector B. Tractor and crew of 50 went into line and worked as assigned but accomplished little. Tractor was roaded from Sector A, Division II, over skyline road to West Valley, arriving on line at about 11 p.m. Navy crews arrived on fire at about 8 p m Division bosses were taken to their divisions by daylight and shown their assignments and were later sent to their starting points. One crew of 50 men got lost in the burn after being on their line and did not again get lined up until 3 a m. by Willingham. Accomplishments were not as good as expected Line was not completed. All sections of sector remained very hot all night and although it was not a running fire, it was very hot but not too hot for working trained hand crews.

One cat broke down near Wood Valley which also contributed to failure to mopup this sector completely during night.

Division III, Sector A. One hundred men arrived on fire line at about 7 p.m., worked line as assigned. Material heavy, fire line was hot all night. Crews did not accomplish as much as was expected Line was not tied into Sector B, Division II. ¼ mile of cold trail and ½ mile of hot spot line was constructed west of Lawson Valley Road on this Sector.

Division III, Sector B Two tractors continued to work until dark. One tractor had no lights, other tractor operated until line was constructed to canyon bottom, approximately 1 mile from starting point.

Section of line in last year's burn Honey Spring fire died out in light material and went out.

Division IV. Two tank trucks continued backfire along road. Fifty-man crew arrived on fire at about 11 p.m. and did mopup work on line This section of line was not entirely completed as planned Approximately ½ mile remained to be backfired on east end of line. Crews continued to backfire until line was completed, at about 9 a.m..

Summary. Not all work planned on Divisions II and IV was completed. On Division IV, this was not serious since the fire was not crowding the backfire line in the area not fired. Crews were slowed up because of spot fires occurring on south side of road that had to be picked up. On Division II, Sector B, and Division III, Sector A, the fire boss underestimated the length and difficulty of line to be worked and misjudged the amount of work that could be accomplished by crews assigned.

Plan of Action—Day Shift—October 2, 1945:

11 p.m., October 1, 1945

Plans were completed to divide the fire into two zones. The Lyons Valley camp to continue to operate. All lines east of the Lawson Valley road to be handled by this camp. A new camp was planned to be established in the vicinity of Jamul, all line west of Lawson Valley road to be taken over by this camp.

4 a.m., October 2, 1945 Status of fire:

Two scouts reported fire had changed very little during night Fire lines on Divisions II and III remained hot during night Fire spread some along these lines no runs occurred to materially change the size of the fire or line location.

Size of fire: 5,600 acres

Fire line controlled: 14.3 miles.

Fire line uncontrolled. 6.5 miles.

It was decided to divide the fire into two zones. All of fire line east of Lawson Valley road to be Zone A. All fire line west of Lawson Valley to be Zone B. The new fire camp for Zone B to be set up in the vicinity of Jamul This zone to be handled by Ewing. The Lyons Valley Camp to remain intact for Zone A. Zone to be handled by Sindel. A second fire team had been requested for Zone B. The Modoc Team would take over Zone A. This would free the Cleveland Team to assist the two off-Forest teams and to coordinate work between the two zones.

Action and Accomplishment: Division I. Other than a small spot outside the line in early morning that was controlled very quickly, there was no real activity on this division of the fire. The entire division was completely mopped up during the day.

Division II. This division east of Wood Valley held. Some mopup was done However, crews were pushed through to Wood Valley area to try to catch up hot fire line in that area One tractor tried to work from the east (secondary line) in to Wood Valley. This tractor broke down (transmission went out). Operator got it into burn and was later pulled out to road by the other tractor. Line was not tied into Wood Valley. Fire started to make run west where line was not worked at about 10 a.m. One tractor in Wood Valley started line west and south, was not able to tie into hand line to west. At this same time crews that had started in to try to work line from Division III Lawson Valley road east and south had to be pulled out. Crews were late (about 8:30) getting out, really never got on line to start work except to hot spot. Crew on Sector A did effective work. Men were pulled back to Beaver Hollow Junction on Division III

Division III, Sector A Crews were late getting out to fire line Arrived at Jamul at 7 a.m. on fire line, about 8 a.m. at Beaver Hollow Junction. Had to be fed, organized, and gotten on the fire line.

One crew dispatched to try to tie line in east to Division II. See above. Other hand crews and tractors started line down ridge from Lawson Valley road west ... to work backfire line ½ mile down ridge, then into Beaver Hollow road. Reason for working line instead of using road for backfire was to bypass a large number of cabins (homes) along the south side of Beaver Hollow road in this area Approximately 0.7 mile of line was successfully held. Tractors were trying to work line down slope into Beaver Hollow road when fire started run from the east behind them. Line was not completed into road One tractor, a Navy D-3, became stuck on steep ground, had to be abandoned by crews and later burned up From 10 to 11 a.m. the fire started making run over this entire sector.

Division III, Sector B Eighty men were spread out over this line. Line was completed from where fire crossed Lyons Valley Road west to southwest corner of fire, from there north almost to Main Ridge southeast of McGinty Peak Most of this line was in light material all held with very little patrol or mopup.

Division IV Crews and tankers mopped up

this entire divisio i as planned.

Summary: Two hundred men ordered to arrive on fire at noon did not arrive until after fire on Divisions II and III had st. .t. . . It was not possible to place them on the fire and do any really effective work during the afternoon.

After the break in the lines on Divisions II and III, it looked as though the fire would go to the Sweetwater River north. Wind changing to southeast and south. It was decided that an attempt to hold the north side of the fire would be made, starting at the Junction of Beaver Hollow and Sweetwater River, east to Sloan Ranch, southeast up Lawson Creek To attempt to cut the east (head) of the fire off in the vicinity of the Lawson Valley Road With this in mind instructions were issued changing the location of the new fire camp from Jamul to the Sweetwater Dam. This was accomplished and the Sweetwater Camp was established in time to get night overhead and crews out from that side of the fire.

Day crews and tractors were shifted from Divisions II and III to the Lawson Valley area and some work was accomplished East from where the fire crossed the Lawson Valley Road near the junction of the Sloan Ranch Road.

Plan of Action—Night Shift—October 2, 1945:

11 a.m., October 2, 1945. A check of the fire had shown that the south line of the fire could be held, the west side would probably hold owing to light cover and in most places fire would be backing down slope, and the north side of the fire was probably all lost from McGinty Peak east to the Lawson Valley Road. With this information, plans were made to shift the division of fire zones The north side of the fire to be one zone with a camp in the vicinity of the Sweetwater Dam. The south side of the fire to be handled as a zone from Lyons Valley Fire Camp

The camp equipment already ordered for a camp at Jamul was sent to Sweetwater Dam. All incoming overhead was dispatched to Sweetwater Dam. Overhead was already in Lyons Valley Camp from previous shifts

4 p.m. Fire still running to north and east in Beaver Hollow area, was near top of Sequan Peak, had crossed Lawson Valley road northeast of Wood Valley; head of fire burning east in South Fork of Lawson Creek; wind shifts to west-northwest.

Size of fire: 7,000 acres
Fire line controlled: 14.5 miles
Fire line uncontrolled: 7 miles
Lyons Peak weather, October 2
8 a.m., T° 77 — Humidity 15 — Wind ESE 12
12 noon, T° 84 — Humidity 10 — Wind SSE 17
4 p.m. T° 74 — Humidity 17 — Wind W

Organization and Strategy To hold all line already constructed on southside of the fire from point south of McGinty Peak to the head of the fire in the vicinity of the junction of the Skyline truck trail and Lawson Valley-Lyons Valley truck trail. Continue cold trail line on west flank of fire in the vicinity of McGinty Peak and work this line north toward Sweetwater River. To start crews to cut the head of the fire off from Skyline truck trail north into Lawson Valley. To also start crews in Lawson Valley to work southeast on fire line to cut head of fire off. To work a crew from junction off Lawson Valley road and Sloan Ranch road to backfire Lawson Creek and keep ahead of main fire. To do no work on the fire line between Sloan Ranch and Beaver Hollow road.

If fire should back into Sweetwater River, tank trucks from State Division of Forestry and Navy to be called to backfire and hold fire along the Sweetwater River. The Sweetwater is an excellent natural barrier consisting of a wide flat gravel bed, several hundred feet wide in most narrow places. A good stream of water flowing down the canyon at all times. The northeast end of the fire now the dangerous threat.

Action and Accomplishment: Zone A. Only 88 of 100 men arrived; one unit got lost and returned to Camp Elliott

Zone A, Division I. Crew worked as assigned. Backfire successful with one dangerous slopover, which was caught up and cold-trailed. Tractor arrived on line at 2 a.m. and completed ½ mile of line down canyon beyond backfire crews. Backfire successful to point where main fire had burned almost into canyon. From that point on backfire impossible to make burn and clean up

Zone A, Division II. Crews started and worked as assigned; were not able to tie line through to head of fire. Fire burned quite hot through night. Tractors did not arrive on fire line until daylight, they then started secondary line on Lawson Valley Road.

Zone B. Only [illegible] of 100 men requested arrived on fire Other men became lost and turned back to their base camp.

Zone B, Division I. Twenty-man crew went into McGinty Peak area as assigned. Were able to cold trail fire and keep up with west flank. Remainder of Division all held without mishap.

Zone B, Division II. Entire Division held as planned.

Zone B, Division III. Crews went to line and started work as assigned Fire burned very hot on the east end of Division all night. Crews were not able to establish themselves on cold trail line and hold it. Fire jumped skyline road early in the afternoon on lower end, early in night on upper end. Was picked up and cold-trailed before morning. Tractors started work from skyline road and worked north on head of fire. Due to rough area, they could not get completely around the head of the fire. One tractor started work in Lawson Valley to work south-

Appendix D

Wildland Fire Spread Data

The following tables contain rate-of-spread and associated data for large wildland fires. They have been separated into four groups according to the length of time over which the rate of spread was calculated. They were grouped because the rates of spread show a strong tendency towards time dependence and also because the weather data are related to each group in a different way.

Group I—6–11 hours: Weather measurements taken at 3 p.m. or midnight if the period includes either of those times. Otherwise, weather measurements taken at the hour nearest to 3 p.m. or midnight. Examples: fire spread measured from 6 a.m. to noon, weather measured at noon; fire spread from 4 p.m. to 10 p.m., weather measured at 4 p.m.

Group II—12 hours: Weather measurements taken at 3 p.m. or midnight.

Group III—13–23 hours: Weather measurements taken at 3 p.m. or midnight, whichever time was most representative of the period of active fire spread as established from the narrative report.

Group IV—24 hours. Weather measurements taken at 3 p.m.

Explanation of Table Headings

FIRE

Fire No. An identifying number assigned to each fire.

Line No. A number-letter combination identifying the burning period and the location where fire spread was measured.

Time of start: The time when the rate of spread measurement was started.

Hours of spread: The length of time over which spread was measured

WEATHER

Wind vel.: Measured wind velocity, in miles per hour.

Temp.: Dry bulb temperature, in degrees Fahrenheit.

RH: Relative humidity, in percent.

Stick: Moisture content of ½-inch pine dowels, in percent.

BI: Burning index as measured by the Wildland Fire Danger Rating System.

FUEL

Predominant fuel types along the line of fire spread. G is grass, B is brush, T is conifer timber, and H is hardwood timber.

TOPOGRAPHY

SLOPE.

UP:

%: The proportion of the line of fire spread where the fire was traveling upslope.

Aver. deg.: The average steepness in degrees of the upslope portion of the line of fire spread

DOWN: Same as UP

Percent Flat: The proportion of the line of fire spread where the fire was traveling across level ground.

Sketch: A vertical profile of the path of the fire, which is always moving from left to right.

SPREAD

Rate. Rate of fire spread in miles per hour.

Angle to wind: Direction of fire spread in degrees relative to the wind direction. O is fire spreading directly with the wind; 180 is fire spreading directly against the wind. All angles less than 90 are with the wind, all angles between 90 and 180 are against the wind.

Type: The manner in which the fire was spreading in the area where the rate of spread was measured. Determined from the original reports. H is a head fire, R is a rear or backing fire, F is a flank, and O is a circular fire or indeterminate.

steep area in which the fire was burning. However, crews on both flanks were able to keep secondary lines well ahead of the head of the fire and were able to backfire a[illegible] lines.

A change in strategy during the day was made approximately 2 p.m. The new strategy was to backfire the Carveacre truck trail to the Gaskell Peak fire, including that fire in the Lyons Peak fire burn, construct a line from the Smiley Ranch to the north line of the Gaskell Peak fire and backfire. Due to weather conditions in the lower elevation in Sweetwater River, the loss of the small section of line in lower Beaver Hollow was not serious.

Plan of Action—Night Shift—October 3, 1945:

1[illegible]30 a.m., October 3. Conditions on the fire indicated that control would not be accomplished during the day. Manpower order for the night shift was placed. Manpower orders were based on the overhead available to handle men on the line.

4 p.m. Status of fire:

Some overhead had been shifted to Descanso fire. All lines previously constructed were holding. Head of fire in vicinity of Lawson Peak was making small runs, but crews were well ahead of main fire with backfire on road, possibility of completing backfire to Gaskell Peak fire very favorable. Tractor line from Smiley Ranch to Gaskell Peak fire progressing favorably. West end of fire near Beaver Hollow completely laid down, little or no spread occurring. North line of fire from Beaver Hollow to Sloan Ranch doing very little, backing down very slowly in draws leading into Sweetwater, large part of line appears to be out.

Size of fire: 10,300 acres
Fire line controlled. 24.4 miles
Fire line uncontrolled: 6.7 miles
Lyons Peak weather, October 3:
8 a.m. T° 78 — Humidity 28 — Wind SSE 21
12 noon T° 82 — Humidity 27 — Wind W 8
4 p.m. T° 77 — Humidity 28 — Wind W 3

Organization and Strategy: Strategy was to patrol and hold all line already constructed To continue to allow the section of line between Beaver Hollow and Sloan Ranch go unworked. To work the west line from end of present cold trail line into Sweetwater River and mop it up. To complete backfire on south line in vicinity of Lawson Peak to tie in with Gaskell Peak fire and mop-up this line. To complete line from Smiley Ranch to Gaskell Peak fire and backfire line.

Zone A, Division I, Sector A Fifty men assigned to west line of fire To cut cold trail, from end of present cold trail, around west [illegible] of fire. To [illegible] a wide fire-break from NW c[illegible]ner of fire to Sweetwater Road. To continue cold trail east on north line of fire. Division I, Sector B, to be patrolled by tanker crew only.

Zone A, Division II. Seventy-five men and one tank truck assigned. Complete and mop-up all line on the division. Mop-up needed over entire line from junction of Lawson Valley and Sloan Ranch road to Smiley Ranch.

Zone A, Division III. Seventy-five men and 4 tractors assigned. Continue backfire line already started from Smiley Ranch to tie in with crew working down from Gaskell Peak fire. When line is completed backfire from Gaskell Peak fire down and tie in line.

Zone B, Divisions I and II. No crews assigned.

Zone B, Division III, Sector A. Eighty men, one tank truck, four tractors assigned. Continue to mop-up line Backfire all line that did not burn out completely, leave no islands, mop all line up completely along Wisecarver Truck Trail.

Zone B, Division III, Sector B. Continue to cut secondary line from northeast end of Gaskell Peak fire west to meet crew working from Smiley Ranch. As soon as line is completed start backfire from top down Do not backfire until line is completed unless necessary.

Action and Accomplishment: Zone A, Division I. All fire line previously constructed held Cold trail along west side of fire in Beaver Hollow area completed. Secondary line from northwest corner of fire completed to Sweetwater road. Fire line from secondary line east to Beaver Hollow road hot spotted.

Zone A, Division II. All line patrolled, partially mopped up. No break in line during shift.

Zone A, Division III. Tractors completed backfire as far as possible for them to go. Short section 0.2 miles to be worked by hand not completed. Tractors worked on secondary line from open field near Smiley Ranch east to tie in with line worked down from Gaskell Peak fire. This line was completed.

Zone B, Division I and II All lines held, appear dead out.

Zone B, Division III. All line completed along Carveacre truck trail to Gaskell Peak fire. Some islands between Lawson Peak and Gaskell Peak did not burn out good. More firing out and mop-up needed. Backfire would not burn after midnight. Tractors moved to east of Gaskell Peak and secondary line [illegible] northwest [illegible] upper Lawson Creek.

Summary. All lines worked as planned. Crews assigned were not able to complete backfire line from Smiley Ranch to Gaskell Peak because of burning conditions Very rough and steep area, difficult for night crews to work Backfiring was very slow and did not clean up well because of rising humidities.

(The fire continued to spread sporadically for the next two days, when control was completed, but its behavior was such that no useful data on rates of spread could be ascertained.)

Appendix C

Example of an Urban Fire Case History

(Note: The following case history is based on Williams' (1954) book *Baltimore Afire*, published and copyrighted by Schneidereith & Sons, Baltimore, Maryland. Excerpts and illustrations are reproduced with permission of the copyright owners.)

The Baltimore Fire of February 7–8, 1904

The fire started at 10:48 a.m., Sunday, February 7, 1904, in a 6-story brick building occupied by a drygoods firm. Between this time and 5 p.m. the next day—a period of 30 hours—the fire burned out 77 blocks. It swept through 139 acres in the heart of downtown Baltimore (figs. 19, 20, 21) and destroyed 1,526 large buildings.

Heavy "builtupness" and moderate wind speed were the factors favorable for fire spread. Other conditions were generally unfavorable. The sky was overcast. Snow lay on the ground and muddy slush at intersections. Relative humidity ranged in the 80's and 90's, and the temperature ranged in the 50's and 60's. Yet flying brands set fires up to 5½ blocks ahead of the main fire front.

Although the fire occurred more than half a century ago, the buildings destroyed were substantial skyscrapers, even by present day standards. Many were rated

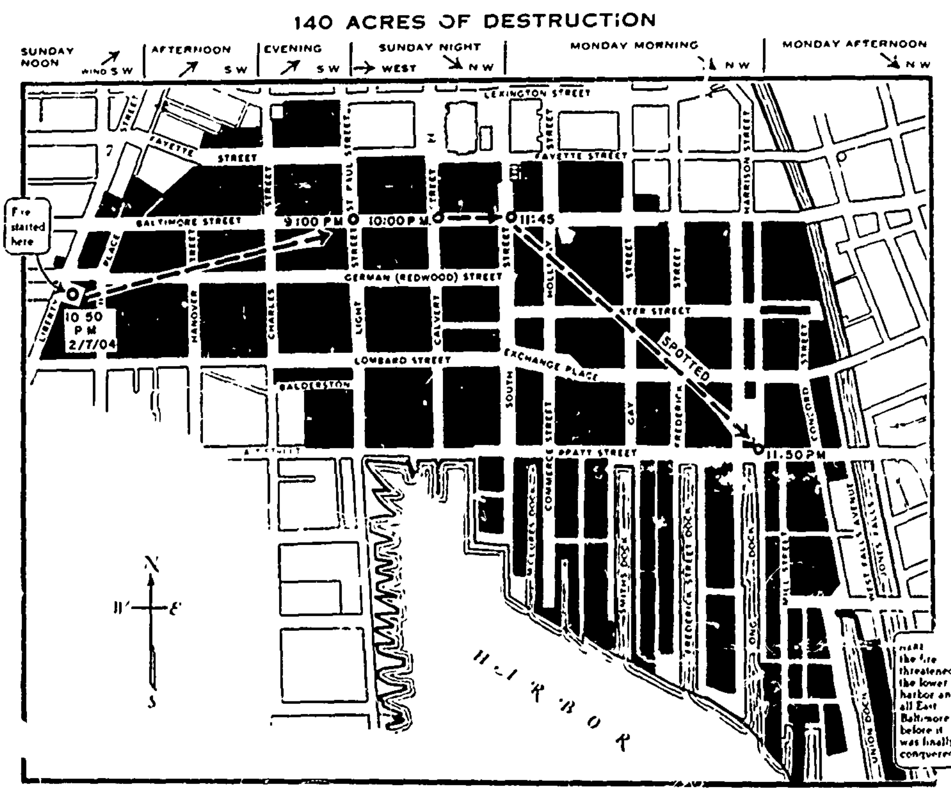

Figure 19.—Map of the Baltimore Fire, showing the approximate midpoint of the fire front at various times and final burned out area. (Reproduced from *Baltimore Afire*, published and copyrighted by Schneidereith & Sons, Baltimore, Maryland.)

Figure 20.—Baltimore after the fire, looking down Lombard Street. Brick buildings crumbled. Fireproof buildings were gutted. The Continental Trust Building is behind the large structure at left center. (Reproduced from *Baltimore Afire*, published and copyrighted by Schneidereith & Sons, Baltimore, Maryland.)

Figure 21.—Baltimore after the fire, looking southwest. The street to the right is Charles. Smoke was still rising from the ruins. (Reproduced from *Baltimore Afire*, published and copyrighted by Schneidereith & Sons, Baltimore, Maryland.)

Figure 20.—Baltimore after the fire, looking down Lombard Street. Brick buildings crumbled. Fireproof buildings were gutted. The Continental Trust Building is behind the large structure at left center. (Reproduced from *Baltimore Afire*, published and copyrighted by Schneidereith & Sons, Baltimore, Maryland.)

Figure 21.—Baltimore after the fire, looking southwest. The street to the right is Charles. Smoke was still rising from the ruins. (Reproduced from *Baltimore Afire*, published and copyrighted by Schneidereith & Sons, Baltimore, Maryland.)

"completely fireproof" In Williams words: ". . . The sixteen-story completely fireproof Continental (Trust Building), tallest in Baltimore, burned like a torch . . ." Another "fireproof" skyscraper burned "as if it [illegible] made of matchwood and drenched with gasoline . . " The burned portion of the city probably is representative of large sections of many American cities today

Relatively little influence was exerted by fire suppression action since the fire was so large that it overwhelmed nearly all efforts to control the flames The fire was finally stopped by the water edge of the harbor; Jones Falls, a slough 75 feet wide; more favorable weather conditions; and some effective fire control action along the Falls.

Weather Conditions.—Weather data during the period of the fire were taken by the U.S. Weather Bureau office, near the fire area in downtown Baltimore.

edges of the fire toward St Paul Street where buildings caught fire by 9 o'clock. . .

"At 9 o'clock the Bank of Baltimore, on the northeast corner of Baltimore and St. Paul Streets, caught fire. From there the flames ate through the Exchange Building of the Calvert Building, the first of the fireproof skyscrapers to catch. . .

"By 10 o'clock the solid Baltimore and Ohio Railroad Building, on the northwest corner of Baltimore and Calvert, was burning. At 10:15 the 16-story 'completely fireproof' Continental Trust Company Building, the tallest one in town, was afire. . . .

"The flames in the area bounded by Fayette, Calvert, German, Light and St. Paul Streets were unusually intense. Firemen estimated that the blaze here developed 2,500 degrees of heat. When the Carrollton Hotel, on

Date and time	Wind speed	Wind dir.	Rel. humid.	Temp.	Sky
	M.p.h.		*Percent*	°F.	
Feb. 7, 1904:					
8 a.m.	1	SW	96	41	--
10 a.m.	2	S	--	48	overcast
12 noon	20	SW	--	64	--
2 p.m.	16	SW	--	60	--
4 p.m.	18	SW	--	60	--
6 p.m.	11	SW	--	58	--
8 p.m.	14	W	84	58	--
10 p.m.	22	W	--	60	--
12 p.m.	22	NW	--	53	--
Feb. 8, 1904:					
Morning	brisk	NW	--	[1]30	clear
Afternoon	brisk	NW	--	[1]30	--

[1] *Estimated.*

Mild weather February 6, the day before the fire, had melted most recent snow, but some snow and slush remained on the ground The wind, which appeared to shift direction frequently, contributed to the difficulty of fighting the fire Thousands of wind-carried firebrands spread the fire more than five blocks ahead of the main fire front.

Fire spread.—The rate of spread was computed from times given in the narrative account and distances scaled from the fire map Locations of the fire front at various times as given in the narrative were plotted on the fire map to determine distances

Significant excerpts from the narrative account follow:

". . . The fire started (at 10:48 a m) in the Hurst Building which stood on the south side of German Street at Liberty. Smoke explosions flared it west and south, but fresh winds from the southwest carried the broad front of the blaze to the northeast. By 3 p.m. much of the area between Fayette and German Streets and west of Charles was in flames already burned. At 7:30 p.m. the wind changed to the west, carrying the ragged eastern

the southeast corner of Light and German, was blazing from top to bottom firemen could not get within a block of it because of the terrific [illegible] and the flying sparks which swept the area like hail. . . .

"Shortly after 11.30 o'clock a cornice of the old Sun Iron Building on the southeast corner of South and Baltimore Streets was struck by falling brands. The first blaze was quickly put out. Fifteen minutes later (at 11:45 p.m.) the American Building, directly across South Street, caught fire and burned fast. More brands fell on the Iron Building.

"Five blocks to the east, sparks set fire to the roof of the old and historic Maryland Institute, scene of many political conventions, in Centre Market Space at Baltimore Street. The building burned for three-quarters of an hour before a stream of water was played on it. . .

"At 11 p.m. the wind changed to the northwest and reached a maximum velocity of 30 miles an hour. At that time flames were racing down Baltimore Street as far as South Street and cutting through the financial district in a southeasterly direction toward the waterfront.

"At 3 a.m on Monday the southern edge of the fire, which had been checked along Lombard Street, finally crossed Charles and moved down to Pratt Street. By 4 a.m. the north side of Pratt was blazing almost to the Falls. By some quirk of wind, one tip of the fire turned at the Falls and went rushing back to the west almost to Cheapside through the dock area.

"A last-ditch fight was made along the Falls with thirty-seven fire engines. By 11 a.m. fire had destroyed practically everything to the Falls from Baltimore Street to the tip of Union Dock. Carried by the northwest wind, sparks started dangerous blazes on the *east side of the stream* in the vicinity of Union Dock but these were contained and conquered. The Great Fire was under control by 5 p.m. Monday."

The last documented spread, by spotting terminating at the corner of Harrison and Pratt Street, was obtained from another case history of this fire.

Appendix D

Wildland Fire Spread Data

The following tables contain rate-of-spread and associated data for large wildland fires. They have been separated into four groups according to the length of time over which the rate of spread was calculated. They were grouped because the rates of spread show a strong tendency towards time dependence and also because the weather data are related to each group in a different way.

Group I—6–11 hours: Weather measurements taken at 3 p.m. or midnight if the period includes either of those times. Otherwise, weather measurements taken at the hour nearest to 3 p.m. or midnight. Examples: fire spread measured from 6 a.m. to noon, weather measured at noon; fire spread from 4 p.m. to 10 p.m., weather measured at 4 p.m.

Group II—12 hours: Weather measurements taken at 3 p.m. or midnight.

Group III—13–23 hours: Weather measurements taken at 3 p.m. or midnight, whichever time was most representative of the period of active fire spread as established from the narrative report.

Group IV—24 hours: Weather measurements taken at 3 p.m.

Explanation of Table Headings

FIRE

Fire No.: An identifying number assigned to each fire.

Line No.: A number-letter combination identifying the burning period and the location where fire spread was measured.

Time of start: The time when the rate of spread measurement was started.

Hours of spread. The length of time over which spread was measured.

WEATHER

Wind vel.: Measured wind velocity, in miles per hour.

Temp.: Dry bulb temperature, in degrees Fahrenheit.

RH: Relative humidity, in percent.

Stick. Moisture content of ½-inch pine dowels, in percent.

BI: Burning index as measured by the Wildland Fire Danger Rating System.

FUEL

Predominant fuel types along the line of fire spread: G is grass, B is brush, T is conifer timber, and H is hardwood timber.

TOPOGRAPHY

SLOPE:

UP:

%: The proportion of the line of fire spread where the fire was traveling upslope.

Aver. deg.: The average steepness in degrees of the upslope portion of the line of fire spread.

DOWN: Same as UP

Percent Flat: The proportion of the line of fire spread where the fire was traveling across level ground.

Sketch: A vertical profile of the path of the fire, which is always moving from left to right.

SPREAD

Rate. Rate of fire spread in miles per hour.

Angle to wind: Direction of fire spread in degrees relative to the wind direction. O is fire spreading directly with the wind; 180 is fire spreading directly against the wind. All angles less than 90 are with the wind; all angles between 90 and 180 are against the wind.

Type: The manner in which the fire was spreading in the area where the rate of spread was measured. Determined from the original reports. H is a head fire, R is a rear or backing fire, F is a flank, and O is a circular fire or indeterminate.

GROUP I—6-11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Per cent Flat	Sketch	Rate	Angle to Wind	Type
3	1A	1300	6	18	82	29	45	35	B	80	14	—	—	20		0630	179	R
	1B	1300	6	18	82	29	45	35	B	30	15	50	18	20		0396	102	F
	1C	1300	6	18	82	29	45	35	B	10	10	50	10	40		.4440	11	H
	1D	1300	6	18	82	29	45	35	B	—	—	80	10	20		1270	17	H
	2A	1900	11	14	67	43	60	16	B	—	—	100	12	—		0219	6	H
	2B	1900	11	14	67	43	60	16	B	40	29	45	20	15		0520	0	H
4	1A	1145	6¼	30	969	127	28	24	TB	100	22	—	—	—		.0683	13	H
	B	1145	6¼	30	958	129	28	24	TB	70	20	30	11	—		.1207	25	H
	1C	1145	6¼	30	951	132	2.8	24	TB	70	18	30	19	—		1428	40	H
	1D	1145	6¼	30	993	115	28	24	B	—	—	80	14	20		.0856	82	F
	2A	1800	6	30	73.4	170	22	24	T	—	—	100	35	—		0159	103	R
	2B	1800	6	30	66.8	181	22	24	B	100	17	—	—	—		.0159	105	F
	2C	1800	6	30	664	179	22	24	B	75	19	25	6	—		0587	22	H
	2D	1800	6	30	700	16.4	22	24	B	45	16	20	24	35		0508	11	F
	2E	1800	6	30	696	165	22	24	B	65	10	—	—	35		0430	5	H
	2F	1800	6	30	696	166	22	24	B	65	2	—	—	35		0430	1	H
	2G	1800	6	30	701	16.4	22	24	B	70	12	30	8	—		0540	41	H
	2H	1800	6	30	717	157	22	24	B	65	25	35	32	—		0713	78	H
	3A	2400	6	20	669	141	22	25	B	75	18	25	34	—		0253	30	H
	3B	2400	6	20	705	126	22	25	B	10	27	35	28	55		0747	27	H
	3C	2400	6	20	729	116	22	25	B	—	—	65	18	35		1667	16	H
	3D	2400	6	20	723	119	22	25	B	30	12	40	34	30		0920	0	H
	3E	2400	6	20	721	119	22	25	B	20	6	80	28	—		0778	16	H
	3F	2400	6	20	733	115	22	25	B	—	—	100	21	—		0667	24	H
	4A	0600	11	10	894	14.7	20	25	B	—	—	100	28	—		0135	4	H
	4B	0600	11	10	983	111	20	25	B	25	29	75	14			[illegible]	66	F
	4C	0600	11	10	983	111	20	25	B	65	30	35	33			047[illegible]	3	H
	4D	0600	11	10	975	112	20	25	B	55	23	45	11			[illegible]	13[illegible]	[illegible]
	4E	0600	11	10	932	131	20	25	B	80	24	10	17	10		1410	150	H
	4F	0600	11	10	937	129	20	25	TB	65	16	20	36	15		.1350	137	H
	4G	0600	11	10	950	12.4	20	25	TB	100	22	—	—	—		1111	150	H
	4H	0600	11	10	973	115	20	25	TB	100	24	—	—	—		0508	165	F
	4I	0600	11	10	930	108	20	25	TB	100	14	—	—	—		0461	135	F
	8A	0800	10	2	952	147	11	13	T	—	—	100	60			0088	140	R
	8C	0800	1[illegible]	2	986	134	11	13	B	—	—	45	23	55		0191	120	F

GROUP I—6 11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
4	8C	0800	10	2	97.8	13.7	11	13	TB	70	18	30	31			0381	135	F
5	1A	1200	6	8-15	107	8	2	40	GB	100	17					1250		H
6	1B	1000	6	6	99	13	15	18	GB	45	11			55		3583	46	"
7	1A	[illegible]	8	18	97	35	45	31	GB	55	12	35	12	10		.2875	58	H
8	1A	1000	6	12	73	45	65	11	B	65	14	20	16	15		1667	13	H
9	1A	1400	6	11	77	33	25	18	GB	20	10	[illegible]	21	60		.2025	24	H
	1B	1400	6	11	79	34	25	18	B	25	10	40	16	35		.2500	12	H
	1C	1400	6	11	79	34	25	18	B	55	16			45		.1360	21	F
10	1A	1100	6	23	94	20	30	64	B	35	12			65		.5170	2	H
12	1A	0930	8½	4	73	30	85	7	TGH	75	23	25	31			.0588	125	H
	1B	0930	8½	14	72	30	85	21	TGH	100	19					.0824	172	H
13	1A	1200	6	12	85	25	35	29	GBH	15	24			85		2333	23	H
14	1A	2200	8	6	68	22	45	13	B	100	16					.0550	9	"
	1B	2200	8	6	68	22	45	13	B	100	11					0600	14	H
15	1A	1130	6½	7	90	25	6	8	G			65	10	35		.0433	166	R
	1B	1130	6½	7	88	26	6	8	G	4[illegible]	15	55	10			.0433	117	H
22	1A	1130	6½	8	99	17	5	16	BG	50	11	30	10	20		.2000	12[illegible]	H
23	1A	1445	6¼	9	62	29	95	16	T			100	10			.0490	49	H
	1B	1445	6¼	9	62	29	95	16	T			100	10			0502	1	H
25	1A	1440	6	14-17	100	20	50	26	B	55	11	45	14			.1555	10	H
	1B	1440	6	14-17	100	20	50	26	B			80	13	20		.1000	37	H
	1C	1440	6	14-17	100	20	50	26	B	15	11	85	13			1445	76	H
28	1A	1230	6	12	81	16	40	25	B	20	16			[illegible]		.2550	5	H
	1B	1230	6	12	81	16	40	25	B	25	16			75		.2270	5	H
29	1A	1830	11½	20	59	32	40	57	G					100		.0533	12	H
	1B	1830	11½	20	59	[illegible]	40	57	G					100		.0561	8	H
30	1A	1100	6	20-25	74	32	50	43	T	75	16	25	10			25[illegible]	[illegible]	H
	1B	1100	6	20-25	74	32	50	43	T	55	20	30	10	15		[illegible]	[illegible]	
31	1A	1400	6	5	90	32	50	9	BT	85	12			15		.2580	29	H
	1B	1400	6	5	90	32	50	8	BT	85	12			15		.2620	23	H
	1C	1400	6	5	90	32	50	8	BT	100	10					.1845	12	H
32	1A	1530	6	7	90	26	50	18	B	80	22	20	[illegible]			.0861	140	F
	1B	1530	6	7	90	26	5.0	18	B	100	25					.1305	179	H
	1C	1530	6	7	90	26	50	18	B	[illegible]	16					.0694	135	F
33	1A	0950		4	83	23	5.5	9	BGT			100	2[illegible]			.0389	173	H

GROUP [illegible]our Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
33	1B	0950	6	4	83	23	5.5	9	BGT	50	14	50	23			.0444	120	H
	1C	0950	6	4	83	23	5.5	9	BGT	40	23	40	25	20		.0553	87	H
35	1A	1400	6	15	67	18	2.5	40	BT	15	10	15	17	70		.1470	20	H
37	1A	1230	6	8	86	15	3	25	B	60	13			40		.5200	48	H
	1B	1230	6	8	89	13	3	25	B	60	10			40		.2000	14	H
38	1A	1245	6	14	83	15	3	42	BT					100		.3333	5	H
39	1A	1150	6 1/6	10	88	15	6	18	B	25	19	10	29	65		.3440	12	H
42	1A	1240	6 1/3	16	87	29	4	35	G	80	10			20		.5375	34	H
43	1A	0400	6	3	69	51	6	7	BG	100	30					.0223	162	R
	1B	0400	6	3	69	51	6	7	BG			65	26	35		.0400	21	H
	1C	0400	6	3	69	51	6	7	BG	85	20	15	18			.0633	61	H
44	1A	1400	9	12	86	18	5	18	B	50	9	50	5			.1510	22	H
	1B	1400	9	12	86	18	5	18	B	70	6	30	13			.0378	49	F
49	1A	0913	8 3/4	13	88	29	5.5	18	B	45	10			55		.6419	1	H
	1B	0913	8 3/4	13	90	28	5.5	18	B	40	8	15	8	45		.7367	12	H
	1C	0913	8 3/4	13	90	28	5.5	18	B	30	8			70		.6943	28	H
	4A	0800	10	7	85	13	5	13	BT	35	11	20	10	45		.4500	9	H
	4B	0800	10	7	84	14	5	13	BT	55	11	15	10	30		.5150	8	H
	4C	0800	10	7	87	12	5	13	BT	50	16	20	10	30		.1150	70	F
	4D	0800	10	7	87	12	5	13	BT	100	27					.0450	51	F
	4E	0800	10	7	89	11	5	13	BT	15	8	60	8	25		.1820	122	H
	6A	0800	10	8	76	34	5.5	10	BT	100	13					.0280	134	R
	6B	0800	10	8	74	35	5.5	10	BT	100	16					.0259	103	R
	6C	0800	10	8	77	34	5.5	10	BT	100	7					.0250	90	R
	8A	0800	10	4	85	25	5	9	BT	100	11					.0380	167	R
	8B	0800	10	4	78	28	5	9	BT	100	14					.0180	131	R
56	1A	1300	9	5	87	26	5	10	T			100	10			.0267	10	[illegible]
	1B	1300	9	5	87	26	5	10	T			100	15			.0067	42	H
	1C	1300	9	5	87	26	5	10	T	100	14					.0222	54	H
	1D	1300	9	5	87	26	5	10	T	100	11					.0089	33	H
	1E	1300	9	5	85	27	5	10	T	85	17			15		.1578	46	H
57	1A	1400	8	6	94	10	3.5	18	BT	85	14	15	28			.1625	20	H
58	1A	1230	8 1/2	10	90	13	4	31	T	65	12			35		.2081	13	H
	1B	1230	8 1/2	10	90	13	4	31	T	60	11			40		.2409	9	H
	1C	1230	8 1/2	10	88	14	4	31	T	55	11	25	5	20		.2605	3	H

GRO[illegible] [illegible]-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
62	1A	0900	9	7	80	22	3.5	11	BT	40	18	40	18	20		.0422	83	F
	1B	0900	9	7	79	23	3.5	11	BT	70	13	30	14			.0533	59	F
	1C	0900	9	7	78	23	3.5	11	BT	50	14	50	10			.0888	48	H
	1D	0900	9	7	78	23	3.5	11	BT	45	15	40	14	15		.1045	41	H
	1E	0900	9	7	77	24	3.5	11	BT	35	18	55	10	10		.1490	33	H
	1F	0900	9	7	78	23	3.5	11	BT	55	13	45	12			.1578	28	H
	1G	0900	9	7	76	25	3.5	11	BT	45	14	15	14	40		.1441	16	H
	1H	0900	9	7	78	23	3.5	11	BT	50	17	50	11			.1440	7	H
	1I	0900	9	7	78	23	3.5	11	BT	55	16	25	16	20		.1200	1	H
	1J	0900	9	7	77	24	3.5	11	BT	65	14	15	12	20		.1089	9	H
	1K	0900	9	7	76	25	3.5	11	BT	80	14			20		.0688	14	H
	1L	0900	9	7	77	24	3.5	11	BT	80	10			20		.0511	25	H
	1M	0900	9	7	77	24	3.5	11	BT	100	10					.0423	40	H
63	1A	1400	6	4	101	9	4.5	15	B	100	26					.0300	10	H
	1B	1400	6	4	101	9	4.5	15	B	60	21	40	10			.0867	18	H
	1C	1400	6	4	100	9	4.5	15	B	80	19			20		.1248	30	H
	1D	1400	6	4	99	9	4.5	15	B	100	17					.1499	41	H
	1E	1400	6	4	98	10	4.5	15	B	75	20			25		.1667	49	H
	1F	1400	6	4	100	9	4.5	15	B	100	19					.1300	58	H
64	1A	1300	6	8	61	45	10	7	B	70	20	10	23	20		.1561	34	H
	1B	1300	6	8	59	46	10	7	B	75	23	25	24			.2040	29	H
	1C	1300	6	8	57	47	10	7	B	70	25			[illegible]		.2265	20	H
	1D	1300	6	8	57	47	10	7	B	90	22			[illegible]		.2000	11	H
65	1A	1300	10	15	89	41	9	18	B	25	23	10	14	65		.2087	23	H
	1B	1300	10	15	87	42	9	18	B	30	21	10	12	60		.2279	19	H
	1C	1300	10	15	88	42	9	18	B	20	18	10	15	70		.2450	16	H
	1D	1300	10	15	89	41	9	18	B	20	18	10	[illegible]	70		.2660	13	H
	1E	1300	10	15	90	41	9	18	B	10	15			90		.2660	[illegible]	[illegible]
	1F	1300	[illegible]	15	86	42	9	[illegible]	B	20	16			80		.3421	8	H
67	1A	0730	6½	6	83	14	5.5	13	B			50	16	50		.1908	2	H
68	3A	1100	7	20	76	21	3.5	48	T	10	19	15	[illegible]	75		.4000	9	H
	3B	1100	7	20	74	22	3.5	48	TG	20	19	15	12	65		.4680	5	H
	3C	1100	7	20	76	22	3.5	48	TG	10	13	10	12	80		.5030	1	H
69	1A	0900	[illegible]	10	78	20	3.5	25	B					100		4230	29	H
	1B	0900	6	10	78	20	3.5	25	B					100		.4470	24	H

GROUP I—6-11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg	%	Aver. Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
69	1C	0900	6	10	79	20	3.5	25	B					100		.4660	14	H
	1D	0900	6	10	79	20	3.5	25	B					100		.4600	9	H
	1E	0900	6	10	76	22	3.5	25	B					100		.4430	5	H
71	1F	1100	7	10	80	50	6.5	5	BT					100		.2380	35	H
	1G	1100	7	10	80	50	6.5	5	BT					100		.2030	40	H
	1H	1100	7	10	80	50	6.5	5	BT					100		.1680	47	F
72	1A	0930	10½	3	78	27	5.5	8	T	50	18	50	0			.0380	96	F
	1B	0930	10½	3	77	28	5.5	8	T	55	17	45	12			.0420	61	F
	1C	0930	10½	3	77	28	5.5	8	T	35	10			65		.1160	58	H
	1D	0930	10½	3	78	27	5.5	8	T					100		.1820	49	H
	1E	0930	10½	3	79	27	5.5	8	T					100		.2260	46	H
	1F	0930	10½	3	79	27	5.5	8	T					100		.2460	41	H
	1G	0930	10½	3	79	27	5.5	8	T					100		.2800	36	H
	1H	0930	10½	3	79	27	5.5	8	T			25	10	75		.1860	29	H
	1I	0930	10½	3	79	27	5.6	8	T			100	10			.1320	20	H
	1J	0930	10½	3	79	27	5.5	8	T			100	10			.1340	10	H
	1K	0930	10½	3	79	27	5.5	8	T			30	10	70		.1080	5	H
	1L	0930	10½	3	78	27	5.5	8	T					100		.1080	19	H
	1M	0930	10½	3	78	28	5.5	8	T			50	10	50		.1000	43	F
	1N	0930	10½	3	77	28	5.5	8	T			20	10	80		.0740	60	F
	1O	0930	10½	3	77	28	5.5	8	T	60	10			40		.0560	80	F
	1P	0930	10½	3	77	28	5.5	8	T	70	10	30	10			.0520	102	F
	1Q	0930	10½	3	76	28	5.5	8	T	100	10					.0500	129	R
	1R	0930	10½	3	76	28	5.5	8	T	100	12					.0420	146	R
	1S	0930	10½	3	77	28	5.5	8	T	100	14					.0300	171	R
74	1A	1930	10½	10	70	70	13	3	BT					100		.2413	4	H
	1B	1930	10½	10	70	70	13	3	BT					100		.5710	14	H
	1C	1930	10½	10	70	70	13	3	BT					100		.3110	36	
	1D	1930	10½	10	70	70	13	3	BT					100		.4050	35	H
75	1A	2200	11	[illegible]	53	58	9	5	BTH			100	10			.0127	120	F
	1B	2200	11	[illegible]	53	58	9	5	BTH					100		.0328	80	F
	1C	2200	11	10	51	59	9	5	BTH	80	17			20		.0854	14	H
	1D	2200	11	10	52	58	9	5	BTH	100	18					.0309	4	H
	2A	0900	9	20	57	35	6.5	27	BTH	10	11	65	11	25		.1400	57	O
	2B	0900	9	[illegible]	55	36	6.5	27	BT					100		.1555	36	O

GROUP I—6-11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel	Temp.	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Per. Flat	Sketch	Rate	Angle to Wind	Type
75	2C	0900	9	20	53	37	6.5	27	BTH			25	10	75		.1556	33	O
	2D	0900	9	20	55	36	6.5	27	BTH			100	16			.0911	28	O
	2E	0900	9	20	55	36	6.5	27	BTH			100	17			.0889	40	O
	2F	0900	9	20	53	36	6.5	27	BTH			100	16			.0511	92	O
	2G	0900	9	20	53	37	6.5	27	BTH	20	22			80		.0444	142	O
	2H	0900	9	20	58	35	6.5	27	BTH	70	10			30		.0400	90	O
	2I	0900	9	20	59	34	6.5	27	BTH	10	10	60	10	30		.0555	152	O
76	2A	1200	6	13	77	24	4	29	B			100	10			.0800	22	F
	2B	1200	6	13	77	24	4	29	B			100	10			.1200	5	F
	2C	1200	6	13	77	24	4	29	B			80	10	20		.1600	5	H
	2D	1200	6	13	77	24	4	29	B			80	10	20		.1800	15	H
	2E	1200	6	13	77	24	4	29	B			85	10	15		.2100	20	H
	2F	1200	6	13	78	24	4	29	BT			90	10	10		.3300	24	H
	2G	1200	6	13	78	24	4	29	BT			100	10			.3770	32	H
	2H	1200	6	13	79	24	4	29	BT			65	13	35		.3639	25	H
	2I	1200	6	13	79	24	4	29	BT			75	11	25		.4248	26	H
	2J	1200	6	13	79	24	4	29	BT			90	10	10		.4440	28	H
	2K	1200	6	13	80	23	4	29	BT			100	13			.5570	29	H
	2L	1200	6	13	79	24	4	29	BT	10	18	65	10	25		.8550	36	H
	2M	1200	6	13	80	23	4	29	BT	15	13	60	12	25		.7150	40	H
	2N	1200	6	13	78	24	4	29	BT	30	11	50	13	20		.8675	38	H
	2O	1200	6	13	78	24	4	29	BT	30	13	45	12	25		.8850	46	H
	2P	1200	6	13	78	24	4	29	BT	25	14	50	12	25		.9160	50	H
	2Q	1200	6	13	78	24	4	29	BT	10	13	40	16	50		1.480	53	H
	2R	1200	6	13	78	24	4	29	BT	10	19	50	12	40		.9350	57	H
	2S	1200	6	13	79	24	4	29	BT	10	22	45	14	45		.7900	62	H
	2T	1200	6	13	77	24	4	29	BT			55	16	45		.3900	65	H
	2U	1200	6	13	74	26	4	29	B			100	20			.2000	[illegible]	[illegible]
	2V	1200	6	13	74	25	4	29	B			60	10	40		.1200	81	H
	2W	1200	6	13	75	25	4	29	B			100	10			.0467	38	F
77	3A	1200	8	15	92	20	8	20	BG	60	13	25	13	25		.0760	45	H
	3B	1200	8	15	92	20	8	20	BG	20	19	35	12	45		.0800	30	H
	3C	1200	8	15	92	20	8	20	BG	30	21	50	21	20		.0940	19	H
	3D	1200	8	15	92	20	8	20	BG	[illegible]	11	40	18	40		.1100	13	H
	3E	1200	8	15	92	20	8	20	BG	15	18	30	22	55		.1260	8	H

GROUP I--5-11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
77	3F	1200	8	15	92	20	8	20	BG	10	22	60	15	30		.1420	2	H
	3G	1200	8	15	95	19	8	20	BG	20	15	70	15	10		.1300	11	H
	3H	1200	8	15	95	19	8	20	BG			60	16	40		.1000	18	H
	3I	1200	8	15	95	19	8	20	BG			100	20			.0200	38	H
	3J	1200	8	15	95	19	8	20	BG			100	20			.0140	64	H
	3K	1200	8	15	93	18	8	20	BG			100	14			.0100	102	H
	3L	1200	8	15	93	18	8	20	BG			100	10			.0100	103	H
80	4A	1200	6	13	90	14	6	31	G	25	14	45	28	80		.0666	50	H
	4B	1200	6	13	88	15	6	31	G	40	22	60	17			.0700	39	H
81	2A	1030	8½	18	72	14	5	38	GB					100		.3741	12	H
	2B	1030	8½	18	72	14	5	38	TG					100		.4235	7	H
	2C	1030	8½	18	72	14	5	38	TG					100		.4376	1	H
85	1A	1430	7.5	7	81	24	5.5	10	T					100		.0720	55	H
	1B	1430	7.5	7	81	24	5.5	10	T					100		2580	46	H
	1C	1430	7.5	7	81	24	5.5	10	T					100		2960	37	H
	1D	1430	7.5	7	81	24	5.5	10	T			100	8			.2080	24	H
	1E	1430	7.5	7	81	24	5.5	10	T					100		1572	79	H
	2A	2200	8	5	63	43	6.5	5	T					100		.0275	70	F
	2B	2200	8	5	63	43	6.5	5	T					100		0388	80	F
	2C	2200	8	5	63	43	6.5	5	T					100		0575	75	F
	2D	2200	8	5	63	43	6.5	5	T					100		0388	4	F
	2E	2200	8	5	63	43	6.5	5	T	30	8	70	18			0825	22	F
	2F	2200	8	5	63	43	6.5	5	T	100	14					0325	15	F
	3A	0600	10	15	78	16	5	28	T					100		.0400	96	F
	3B	0600	10	15	78	16	5	28	T					100		0780	90	F
	3C	0600	10	15	79	15	5	28	T	20	21	25	35	55		5500	20	H
	3D	0600	10	15	78	16	5	28	T	55	10	25	12	20		3260	[illegible]	[illegible]
	3E	0600	10	15	78	16	5	28	T					100		2800	[illegible]	[illegible]
	6A	2100	9	14	52	59	7	9	T					100		1730	7	H
	6B	2100	9	14	52	59	7	9	T					100		0910	7	H
	6C	2100	[illegible]	14	52	59	7	9	T					100		1975	4	H
	6D	2100	9	14	52	59	7	9	T					100		0356	14	H
	6F	2100	9	14	52	59	7	9	T					100		0333	21	H
86	1A	1200	6	12	78	27	7.5	18	T					100		7410	6	H
88	1A	1730	6.5	-	9	30	5	12	T	66⅔	18	33⅓	36			28	7	H

GROUP I—6-11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel	Temp.	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Horz'l Fl.	Sketch	Rate	Angle to Wind	Type
88	1B	1730	6.5	8	86	30	5	12	T	100	17					.0050	45	H
	1C	1730	6.5	8	86	30	5	12	T	100	14					.0075	77	H
	1D	1730	6.5	8	86	30	5	12	T	100	23					.0029	95	F
	1E	1730	6.5	8	86	30	5	12	T			100	19			.0025	153	F
89	1A	0900	6	12	94	27	5	18	B	45	24	15	13	40		.0330	52	H
	1B	0900	6	12	95	26	5	18	B					100		.1495	54	H
	1C	0900	6	12	94	27	5	18	B	45	17	30	9	25		.1567	68	H
	1D	0900	6	12	93	27	5	18	B	60	15	40	3			.1865	77	H
	1E	0900	6	12	92	28	5	18	B	60	18			40		.2162	89	H
	1F	0900	6	12	92	27	5	18	B	100	21					.1500	95	H
93	1A	2100	9	3	68	34	6.0	7	B	25	14	75	20			.0490	113	O
	1B	2100	9	3	68	34	6	7	B	45	19	55	27			.0312	93	O
	1C	2100	9	3	68	34	6	7	B			65	31	35		.0466	34	O
	1D	2100	9	3	68	34	6	7	B			40	28	60		.0423	121	O
	1E	2100	9	3	68	34	6	7	B			20	22	80		.0445	145	O
	1F	2100	9	3	68	34	6	7	B					100		.0623	170	O
	1G	2100	9	3	68	34	6	7	B			15	13	85		.0576	174	O
94	2A	0600	11	10	87	23	5.5	18	T	35	15	10	19	55		.1310	84	H
	2B	0600	11	10	88	22	5.5	18	T	100	9					.1071	50	H
	2C	0600	11	10	88	22	5.5	18	T	65	16			35		.0763	51	F
	2D	0600	11	10	88	23	5.5	18	T	55	7			45		.0761	43	H
	2E	0600	11	10	90	21	5.5	18	T					100		.0728	37	H
95	1A	0600	7	39	80	11	4.5	92	G	25	16	20	12	[illegible]		.7540	[illegible]	H
	1B	0600	7	39	80	11	4.5	92	G	40	16	35	21	25		.7770	10	H
97	1A	1230	8	23	89	23	8	39	TB					100		1.1100	25	H
	1B	1230	8	23	89	23	8	39	TB					100		1.1040	22	H
	1C	1230	8	23	89	23	8	39	TB					100		1.0880	23	H
	1D	1230	8	23	89	23	8	39	TB					100		1.0680	19	[illegible]
	1E	1230	8	23	89	23	8	39	TB					100		.9600	21	H
98	2A	0800	10	15	91	40	8	13	B					100		.2222	10	H
	2B	0800	10	15	91	40	8	13	B					100		.3400	18	H
	2C	0800	10	15	91	40	8	13	B					100		.6800	4	H
	2D	0800	10	15	91	40	8	13	B					[illegible]		.3600	8	H
	2E	0800	10	15	91	40	8	13	B					100		.1000	29	H
100	1A	.030	7.	13	104	14	3.5	32	[illegible]					100		.1920	70	F

GROUP I—6-11-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	Fuel	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
100	1B	1030	7.5	13	104	13	3.5	32	B	80	10	20	10			.2110	60	F
	1C	1030	7.5	13	104	14	3.5	32	B	70	10	30	10			.2400	57	F
	1D	1030	7.5	13	103	14	3.5	32	B	50	10			50		.2290	48	F
	1E	1030	7.5	13	103	14	3.5	32	B	50	10			50		.2370	10	F
	1F	1030	7.5	13	104	14	3.5	32	B	60	10			40		.3340	41	H
	1G	1030	7.5	13	104	14	3.5	32	B	65	10			35		.3470	32	H
	1H	1030	7.5	13	105	13	3.5	32	B	35	10	35	10	30		.3230	24	H
	1I	1030	7.5	13	106	13	3.5	32	B	50	10	50	10			.2400	19	H
	1J	1030	7.5	13	106	13	3.5	32	B	50	10	50	10			.2270	12	H
	1K	1030	7.5	13	105	13	3.5	32	B	50	10	50	10			.2110	3	H
	1L	1030	7.5	13	105	13	3.5	32	B	40	10			60		.2080	6	H
	1M	1030	7.5	13	106	13	3.5	32	B	35	10	65	10			.2130	16	H
	1N	1030	7.5	13	106	13	3.5	32	B	35	10	30	16	35		.2210	23	H
	1O	1030	7.5	13	106	13	3.5	32	B	60	10	40	11			.2080	31	F
	1P	1030	7.5	13	105	13	3.5	32	B	60	10	40	10			.1730	31	F
	1Q	1030	7.5	13	106	13	3.5	32	B	70	[illegible]	30	10			.1650	49	F
104	1A	1630	7.5	15	86	6	3	48	B					100		.3578	50	H
	1B	1630	7.5	15	86	6	3	48	B					100		.4451	40	H
	1C	1630	7.5	15	86	6	3	48	B					100		.2880	31	H
	1D	1630	7.5	15	86	6	3	48	B					100		.3020	81	H
	1E	1630	7.5	15	86	6	3	48	B					100		.4960	73	H
	1F	1630	7.5	16	86	6	3	48	B					100		.6350	67	H
106	1A	1300	11	0	94	17	3.5	11	TG	50	12			50		.1909	179	H
	1B	1300	11	0	96	16	3.5	11	TG	50	12	50	10			.1909	172	H
	1C	1300	11	0	97	16	3.5	11	TG	50	10	35	9	15		.1909	164	H
	1D	1300	11	0	97	16	3.5	11	TG	75	7	25	19			.1909	159	H
	1E	1300	11	0	98	15	3.5	11	TG			25	11	75		.168[illegible]	[illegible]48	H
	1F	1300	11	0	98	15	3.5	11	TG					100		[illegible]	135	[illegible]
	1G	1300	1'	0	98	15	3.5	11	TG	25	7			75		.2273	128	H
	1H	1300	11	0	97	16	3.5	11	TG					100		.2864	11°	H
	1I	1300	11	0	97	16	3.5	11	TG					100		.2818	113	H
	1J	1300	11	0	97	16	3.5	11	TG					100		.2636	107	H
110	1A	1245	6¼	6	86	19	4.5	15	T	100	1[illegible]					.1439	5	H
	1B	1245	6¼	6	86	19	4.5	15	T	80	23			20		.1439	2	H
	1C	1245	[illegible]	6	86	19	4.5	15	T	100	15					.0080	16	H

GRO[illegible] [illegible] hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI		%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
110	1D	1245	6¼	6	86	19	45	15	T	90	13			10		.1730	22	H
	1E	1245	6¼	6	86	19	45	15	T			60	10	40		.0054	38	F

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp.	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
1	2A	0600	12	10	94	20	40	24	B	80	25			20		0417	60	F
	2B	0600	12	10	90	22	45	24	B	100	26					0354	15	H
	2C	0600	12	10	90	22	45	24	B	45	15	30	16	25		1500	20	H
	2D	0600	12	10	98	19	40	24	B	60	30	40	25			0450	66	F
	3A	1800	12	0	56	47	65	5	B			95	27	5		0104	—	R
	3B	1800	12	0	58	48	65	5	B			100	11			0312	—	R
	3C	1800	12	0	57	48	65	5	B			100	24			0250	—	R
	3D	1800	12	0	63	46	65	5	B			70	14	30		0375	—	R
	3E	1800	12	0	67	44	65	5	GH			100	11			0312	—	R
	4A	0600	12	10	93	20	40	33	B	50	9			50		2563	59	R
	5A	1800	12	3	63	37	60	8	B			30	24	70		0584	66	R
	5B	1800	12	3	63	36	60	8	B			100	23			0292	128	R
	5C	1800	12	0	58	38	50	7	B	45	33			55		2500	—	R
	6A	0600	12	10	86	28	35	24	BT	100	19					1851	2	H
	6B	0600	12	10	87	27	35	24	BT	100	20					1812	10	H
	6C	0600	12	10	90	26	35	24	BT	80	23	20	11			2082	0	H
	6D	0600	12	10	90	26	35	24	T	90	13			10		2979	73	F
	6E	0600	12	10	93	25	35	24	T	75	8			25		2643	4	H
	6F	0600	12	10	88	27	4.5	24	B	100	12					2200	137	F
	7A	1800	12	3	54	45	55	7	T	100	22					0563	135	O
	7B	1800	12	3	51	45	55	7	T	100	26					0417	159	O
	7C	1800	12	3	48	45	55	7	T	15	17			85		0312	116	O
	7D	1800	12	3	54	44	55	7	B			70	34	30		0275	94	O
	7E	1800	12	0	55	43	50	5	B			100	14			0167	—	O
	8A	0600	12	10	78	27	4.0	24	T	15	23	15	10	70		1200	123	H
	8B	0600	12	10	84	26	4[illegible]	24	BT					100		0208	74	F
	8C	0600	12	10	83	26	40	24	T	30	24			70		0563	[illegible]	F
3	4A	0600	12	11	84	35	55	22	B	[illegible]	10	15	17	35		0146	133	[illegible]
	4B	0600	12	14	84	35	55	22	B			70	11	30		0208	123	R
	4C	0600	12	[illegible]	84	35	55	22	B			100	15			0219	170	R
	4D	0600	12	14	84	35	55	22	B			100	11			0104	154	R
	5A	1800	12	14	67	46	65	15	B			80	11	20		0656	163	R
	30-2C	1800	12	25	71 4	123	22	25	B	40	22	20	31	40		0658	27	H
	30-2D	1800	12	25	731	115	22	25	B	10	16	80	19	10		1083	16	H
	30-2E	1800	12	[illegible]	725	118	22	25	B	35	11	40	33	25		0275	0	H

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Per. Flat	Sketch	Rate	Angle to Wind	Type
4	3E-3F	1800	12	25	[illegible]7	117	22	25	B	40	8	45	30	15		.0595	16	H
5	2A	1800	12	5	73	31	35	10	B					100		0167	100	F
	2B	1800	12	5	73	31	35	10	B			40	18	60		.0417	96	F
6	2A	1600	12	2	79	25	30	8	C			25	49	75		.0292	9	H
	2B	1600	12	2	79	25	30	8	B	55	21	45	13			0667	87	F
7	2A	1800	12	5	66	65	6	4	B	45	15			55		.0917	4	H
	2B	1800	12	5	66	65	6	4	B	50	22			50		0583	21	H
9	2A	2000	12	8	61	58	4	9	B	40	21	60	11			0333	136	R
	2B	2000	12	8	61	58	4	9	B			45	16	55		0625	69	F
	2C	2000	12	8	61	58	4	9	B			20	18	80		.0500	101	F
	2D	2000	12	8	61	58	4	9	B	30	17	25	20	45		.1458	24	H
	2E	2000	12	8	61	58	4	9	B	10	12	25	17	65		.2500	7	H
	2F	2000	12	8	61	58	4	9	B	80	22	20	24			.1250	49	F
	3A	0800	12	7	80	9	3	21	B	60	27	25	16	25		.1332	43	H
	4A	2000	12	10	57	20	35	22	B	55	15	25	24	20		.2540	31	H
	5A	0800	12	8	79	24	4	16	B			45	30	55		.1041	24	H
10	2A	1700	12	14	79	34	45	24	B	100	10					0125	19	H
11	2A	1800	12	18	88	32	5	32	C	70	12	30	19			0666	171	H
12	2A	1800	12	3	65	42	90	6	TGH	35	31			65		0250	172	H
	2B	1800	12	3	65	42	90	6	TGH	35	27	65	19			0458	165	R
	3A	0600	12	8	86	22	65	15	TGH	65	12			30		.0250	110	H
	4A	1600	12	4	65	45	80	6	TGH	10	27	65	16	25		.0750	9	H
	4B	1800	12	4	62	51	85	7	TGH			55	[illegible]	[illegible]		0500	164	H
	4C	1800	12	0	55	45	[illegible]	4	TGH			15	14	85		.0418		H
	5A	0600	12	8	83	27	6.5	15	TGH	40	34			60		.0250	38	H
	5B	0600	12	8	81	28	65	15	TGH	100	10					.0292	91	H
	5C	0600	12	14	80	26	65	28	GH	90	19			10		.156[illegible]	22	H
	6A	1800	12	4	62	54	85	4	GH	100	12					[illegible]	[illegible]	
	6C	1800	12	2	62	54	85	4	GH			100	15			0167	19	F
	7B	0600	12	10	78	27	6	18	GH	55	18			45		0417	163	F
	8A	1800	12	0	62	54	8.5	2	GH	100	35					0083		H
	8B	1800	12	0	62	54	8.5	2	GH	40	27			60		0083		H
	10A	0600	12	8	83	15	5.5	18	GH			50	18	50		0250	102	F
	12A	0600	12	8	78	34	55	12	H	100	18					.0250	58	H
	14A	0600	12	8	77	27	55	15	H	80	17	20	27			.0333	93	H

GROUP II--12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Horizontal Flat	Sketch	Rate	Angle to Wind	Type
14	2A	0600	12	14	88	11	3.0	38	B	65	8	35	11			.2000	34	H
	2B	0600	12	14	89	10	3	38	B	25	5	40	13	35		.2917	10	H
	2C	0600	12	14	88	11	3	38	B	100	10					.0833	9	H
	3A	1800	12	5	64	25	4	11	B	100	3					.0717	54	H
	3B	1800	12	5	64	25	4	11	B			35	15	65		.0500	130	O
	4A	0600	12	16	87	11	3	48	B			100	7			.1481	96	H
	4B	0600	12	16	85	12	3	48	B	45	12			55		.1071	3	H
	4C	0600	12	16	88	10	3	48	B					100		.0500	165	H
	5A	1800	12	2	67	37	5	6	B			100	14			.0333	93	O
	6A	0600	12	22	93	16	4	16	B	85	6	15	13			.0750	102	H
	7A	1800	12	6	72	30	5	10	B					100		.0333	31	H
16	2A	0600	12	10	91	19	5	26	G	40	14	10	27	50		.1400	125	F
17	2A	1800	12	2	63	53	6	4	B			100	10			.0333	20	H
	2B	1800	12	2	63	53	6	4	B	45	10	55	14			.0083	94	F
	3A	0600	12	7	82	44	4	9	B	30	11	35	16	35		.0667	117	H
	3B	0600	12	7	80	44	4	9	B	40	12	20	18	40		.1000	169	H
	3C	0600	12	7	85	43	4	9	B	100	18					.0167	34	F
	4A	1800	12	2	62	57	6	4	B			25	18	75		.0167	31	O
	5A	0600	12	9	85	48	4.5	10	B					100		.0167	173	O
	6A	0600	12	12	61	75	7	3	B	100	27					.0083	147	O
	7A	0600	12	12	61	75	7	3	B	45	10	55	10			.0083	65	O
18	5A	0600	12	11	82	30	4.5	18	B			100	22			.0083	136	R
	6A	1800	12	4	64	49	5.5	5	B	30	22	70	31			.0333	10	H
	8A	0600	12	9	65	36	5	10	B	75	10	25	14			.0083	144	F
	9A	1800	12	8	78	34	5.5	9	B			100	29			.0125	122	F
	10A	1800	12	3	61	60	6.5	3	B			100	10			.0167	38	F
	11A	0600	12	11	77	35	5.5	12	B			100	10			.0083	[illegible]	R
19	2A	0400	12	2	60	26	4.5	8	T	15	28	85	13			[illegible]	141	
	3A	1600	12	3	46	38	5.5	7	T	85	11	15	10			.0500	5	H
	4A	0400	12	3	58	29	4.5	9	T			100	10			.0250	33	O
	4B	0400	12	3	59	29	4.5	9	T					100		.0167	109	O
	5A	1600	12	0	45	50	6	4	T			100	18			.0083		O
	6A	2400	12	8	59	30	5	11	T			100	12			.0333	28	H
	7A	1600	12	4	45	49	6	6	T	75	10	25	18			.0333	48	H
	7B	1600	12	[illegible]	45	49	6	6	T			100	15			.0167	45	F

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Per. Flat	Sketch	Rate	Angle to Wind	Type
19	8A	0400	12	12	59	23	5	19	T			85	12	15		1000	10	H
	9A	1600	12	6	45	37	55	9	T					100		0750	0	H
	9B	1600	12	6	45	37	55	9	T					100		0333	59	F
	10A	0430	12	17	55	24	5	30	T					100		0167	62	H
	11A	1600	12	8	43	36	55	10	T	100	10					0167	91	H
	12A	0400	12	15	56	25	5	25	T	100	27					0167	127	H
20	1A	1800	12	21	54	11	3	78	B			100	20			0502	57	F
	1B	1800	12	21	54	11	3	78	B	75	19			25		0502	127	F
	1C	1800	12	21	54	11	3	78	B	60	15	40	18			.0943	65	H
	1D	1800	12	21	54	11	3	78	B	40	16	50	24	10		1162	45	H
	1E	1800	12	21	54	11	3	78	B	10	13	90	10			.1260	20	H
	2A	0600	12	16	73	9	3	64	B	60	25	25	22	15		.0693	117	H
	2B	0600	12	16	76	10	3	58	B	70	16	30	19			0345	92	H
	3A	1600	12	15	56	16	3	42	B	65	22	35	24			0474	178	H
	3B	1800	12	15	56	16	3	42	B	30	11	70	10			0785	117	H
	4A	1800	12	15	67	9	3	52	B	85	4			15		0504	141	H
	4B	0600	12	15	67	9	3	52	B	35	17	65	11			.2900	12	H
	5A	1800	12	4	58	17	3	13	B	70	17			30		.0286	157	O
	5B	1800	12	4	58	17	3	13	B			30	27	70		0220	76	H
	5C	1800	12	4	58	17	3	13	B			100	22			0315	40	O
	6A	0600	12	10	75	7	25	34	B	60	20	40	25			0378	177	F
	6B	0600	12	10	76	8	25	34	B	45	19	55	16			0503	125	H
	6C	0600	12	10	76	8	25	34	B	20	10			80		.0692	9[illegible]	H
	7A	1800	12	4	62	18	35	13	B	45	17	30	26	25		0252	166	H
21	2A	1800	12	3	64	38	5	6	B	75	26			25		0833	34	H
	2B	1800	12	3	64	38	5	6	B	40	34			60		.1082	1	H
23	2A	2100	12	36	42	42	95	36	GBT					100		1659	29	H
24	2A	1700	12	15-20	65	22	8	37	G	10	10	15	10	75		0372	4[illegible]	[illegible]
26	2A	1000	12	20	82	37	75	25	BT	80	15	20	10			0750	24	H
	2B	1000	12	20	82	37	75	25	T	100	10					0695	25	H
	3A	2200	12	2	65	45	80	4	B	100	16					0167	162	O
27	3A	0800	12	4	68	22	55	7	BT					100		0556	62	H
	3B	0800	12	4	68	22	55	7	BT					100		.0389	7	F
29	2A	0600	12	16	88	12	30	57	G					100		0918	23	H
	2B	0600	[illegible]	16	88	12	30	57	G			30	[illegible]	70		1225	76	H

GROUP II--12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Perct Flat	Sketch	Rate	Angle to Wind	Type
29	2C	0600	12	16	88	12	30	57	G			60	18	40		.1710	52	H
	2D	0600	12	16	88	12	30	57	G	10	18	50	17	40		.1795	7	H
	3A	1800	12	12	64	27	30	32	G	30	11	20	12	50		.2210	94	H
	3B	1800	12	12	64	27	30	32	G	25	12	75	13			.1390	37	H
	3C	1800	12	12	64	27	30	32	G	20	14	56	15	25		.1665	72	H
	3D	1800	12	12	64	27	30	32	G	75	11	25	15			.1125	100	H
	4A	0600	12	3-5	84	17	30	17	BT					100		.0945	40	O
	4B	0600	12	3-5	84	17	30	17	BT			25	13	75		.0945	71	O
	4C	0600	12	3-5	84	17	30	17	BT	15	10	25	10	60		.1975	75	O
	4D	0600	12	3-5	84	17	30	17	BT			15	10	85		.0347	110	O
	5A	1800	12	3	60	38	40	11	BT	100	10					.0333	28	H
	5B	1800	12	3	60	38	40	11	BT	50	10			50		.0806	115	H
	5C	1800	12	3	60	38	4.0	11	BT					100		.0306	140	O
	5D	1800	12	3	60	38	40	11	BT			100	12			.1210	134	O
	6A	0600	12	18	88	18	35	50	BT	35	12	65	12			.1265	7	H
	6B	0600	12	18	88	18	35	50	BT	50	[illegible]	50	12			.1505	14	H
	7A	1800	12	16	64	39	40	36	BT	35	10	15	18	50		.0563	70	H
	8A	0600	12	20	84	21	25	60	BT	85	10	15	18			.0640	16	H
	8B	0600	12	20	84	21	25	60	BT					100		.1015	11	H
	9A	1800	12	16	62	41	40	35	BT	35	11	65	11			.0668	50	H
	9B	1800	12	16	62	41	40	35	BT	50	10	60	10			.1155	57	H
	9C	1800	12	16	62	41	40	35	BT			100	10			.0319	130	F
	9D	1800	12	16	62	41	4.0	35	BT			100	10			.0236	132	F
31	2A	2000	12	3	76	35	50	9	BT	100	9					.0334	152	H
	2B	2000	12	3	76	35	50	8	BT	100	10					.0444	178	H
	2C	2000	12	3	76	35	50	8	BT	100	13					.0389	174	H
	2D	2000	12	3	76	35	50	8	BT	100	10					.2341	[illegible]	H
	3A	0800	12	4	92	22	45	12	BT					100		[illegible]	8	
	3B	0800	12	4	92	22	45	12	BT	60	17	40	10			.1155	8	H
	3C	0800	12	4	92	22	45	12	BT	100	17					.1180	158	H
	3D	0800	12	4	92	22	45	12	BT	100	24					.0722	79	F
32	4A	2130	12	4	74	22	50	9	B	40	34	45	36	15		.0431	147	H
	4B	2130	12	4	74	22	50	9	B	75	21			25		.0264	152	F
	5A	0930	12	6	85	21	4.0	15	B	100	26					.0612	95	H
33	2A	1550	12	0	72	33	60	5	B,T			100	16			.0181		C

GROUP II — 12-Hour Periods

FIRE				WEATHER					FUEL	TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
33	2B	1550	12	0	72	33	6.0	5	BGT			100	17			.0208		O
	2C	1550	12	0	72	33	6.0	5	BGT	40	16	35	18	25		.0292		O
	3A	0350	12	7	85	19	5.5	11	BGT			100	10			.0097	164	R
	3B	[illegible]	12	7	85	19	5.5	11	BGT			100	19			.0222	138	R
34	2A	2200	12	3	52	46	4.5	8	B					100		.0333	48	H
	3A	1000	12	7	61	52	5.5	8	B	40	12	[illegible]	10			.0319	85	F
	3B	1000	12	7	64	52	5.5	8	B			[illegible]	13			.0680	40	H
	3C	1000	12	7	65	51	5.5	8	BH	30	10	70	20			.0556	42	H
	3D	1000	12	7	65	51	5.5	8	BH	65	17	35	22			.0902	9	H
	4A	2200	12	3	59	55	6.0	4	H			100	10			.0139	40	H
	4B	2200	12	3	59	55	6.0	4	H			100	19			.0195	41	H
	4C	2200	12	3	59	55	6.0	4	H			100	32			.0208	14	H
35	2A	2000	12	2	49	41	4.5	6	BT	75	23			25		.0305	71	O
	2B	2000	12	2	49	41	4.5	6	BT	100	7					.0417	15	H
	3A	0800	12	10	63	25	2.5	23	BT	65	10	35	11			.1805	22	H
	3B	0800	12	10	64	26	2.5	23	BT					100		.0305	15	F
36	2A	0700	12	5	81	19	5	10	B	80	13	20	16			.1405	3	H
	2B	0700	12	5	81	19	5	10	B	35	10	65	17			.0806	29	H
	3A	1900	12	3	64	35	5.5	7	BT	60	21	40	30			.0139	54	H
	3B	1900	12	3	64	35	5.5	7	BT					100		.0264	82	H
	4A	0700	12	3	75	18	5	10	BT			100	18			.0319	129	R
37	2A	1830	12	2	64	32	5	6	B	100	5					.0716	55	H
	2B	1830	12	2	64	32	5	6	B	30	14					.0100	40	H
	2C	1830	12	2	64	32	5	6	B	45	8	55	14			.0233	27	O
	2D	1830	12	2	64	32	5	6	B	50	6	50	6			.0100	143	O
	2E	1830	12	2	64	32	5	6	B					100		.0092	70	O
	3B	0630	12	13	74	31	4	24	T	25	14			75		.1283	111	F
	3C	0630	12	13	72	32	4	24	T	65	7	20	21	15		.2450	[illegible]	H
	3D	0630	12	13	77	30	4	24	B			45	9	55		.3840	28	H
	3E	0630	12	13	67	33	4	24	T			60	13	40		.2600	13	F
	3F	0630	12	13	74	31	4	24	T			60	18	40		.2730	22	F
	3G	0630	12	13	67	33	4	24	T			25	6	75		.1330	117	F
42	2A	1800	12	3	69	75	6.5	3	G			100	21			.0052	81	O
	2B	1800	12	3	69	75	6.5	3	G			100	8			.0026	34	O
	2C	1800	[illegible]	3	69	75	6.5	3	G			100	26			.0095	22	O

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver Deg	Horiz. Flat	Sketch	Rate	Angle to Wind	Type
42.	3A	0600	12	14	88	40	5	26	G			75	15	25		.0291	71	H
	3B	0600	12	14	88	40	5	26	G			150	26			.0104	114	O
	3C	0600	12	14	86	40	5	26	G			100	10			.0094	63	O
43.	2A	1000	12	3	90	25	4 5	13	BG	85	34	15	25			.0483	22	H
	2B	1000	12	3	95	27	4.5	13	BG	65	20	35	22			.0667	124	H
	3A	2200	12	2	65	56	6	5	BG	100	22					.0457	134	[illegible]
	3B	2200	12	2	65	56	6	5	BG	25	26	15	16			.0150	81	O
	3C	2200	12	2	65	56	6	5	BG	100	24					.0216	130	O
	4A	1000	12	6	87	20	45	16	BG	100	24					.0112	123	H
	4B	1000	12	6	83	21	45	16	BG	45	25	45	26	10		.1450	102	H
	4C	1000	12	6	83	21	45	16	BG	20	22	50	22	30		.2038	84	H
	5A	2200	12	3	67	41	5.5	9	BG	85	22			15		.0083	126	H
	6A	1000	12	3	87	15	45	13	BG	60	25	40	17			.0384	103	H
	6B	1000	12	3	82	17	45	14	BG	85	26			15		.0384	156	H
46	1A	0600	12	4	87	16	45	12	B	75	10	25	26			.0772	149	F
	2A	1800	12	1	59	36	60	6	B	100						.0010	44	H
	2B	1800	12	1	59	36	60	6	B			50	9	50		.0150	105	H
	3A	0600	12	13	71	48	5.5	15	B	100	14					.0433	112	H
	4A	1800	12	8	57	62	7.5	5	B	85	8	15	22			.0651	3	H
	4B	1800	12	8	57	62	75	5	B	100	3					.0600	7	H
	4D	1800	12	8	57	62	75	5	B			100	19			.0133	47	O
	4E	1800	12	8	57	62	7.5	5	B	100	22					.0314	55	O
	5A	0600	12	6	81	28	7	8	B	20	11	80	3			.0468	30	O
	5B	0600	12	6	81	28	7	8	B			65	15	35		.0650	4	O
	5C	0600	12	6	81	28	7	8	B			70	14	30		.0833	27	O
	5D	0600	12	6	81	28	7	8	B			70	11	30		.0600	39	O
	5E	0600	12	6	81	28	7	8	B			100	6			.066	[illegible]	O
	5F	0600	12	6	81	28	7	8	B			100	13			.0184	101	[illegible]
	6A	1800	12	3	64	28	6	7	B			100	16			.0234	0	O
	6B	1800	12	3	64	28	6	7	B	55	7	45	19			.0332	14	O
	7A	0600	12	10	82	11	4	27	BT					100		.0467	72	H
	7B	0600	12	10	83	[illegible]	4	27	BT			100	12			.0450	10	H
	7C	0600	12	10	82	11	4	27	BT			50	13	50		.1165	11	H
	8A	1800	12	2	67	22	4	27	BT			100	13			.0151	94	O
	9A	0600	12	23	92	9	3	80	[illegible]	60	14	25	15	15		.1816	141	H

GROUP 1 -- [illegible]r Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
46	11A	0600	12	15	74	29	3	33	B	100	16					.0417	13	H
47	2A	0600	12	8	92	23	5	15	B	55	12	15	7	30		.3333	58	H
	2B	0600	12	8	95	21	5	15	B	35	21	20	22	45		.2701	72	H
	2C	0600	12	8	96	20	5	17	B	15	9	70	11	15		.2990	79	H
	2D	0600	12	8	97	20	5	17	B	55	15	45	[illegible]			.1231	82	H
	2E	0600	12	8	97	20	5	17	B	55	10	45	13			.0749	96	H
	2F	0600	12	8	96	21	5	15	B	65	14	35	20			.0500	62	R
	2G	0600	12	8	96	21	5	15	B	60	17	40	14			.0683	111	R
	2H	0600	12	8	95	21	5	15	B	60	15	30	22	10		.0851	111	R
	2I	0600	12	8	93	22	5	15	B	35	24	25	16	40		.0802	99	R
	4A	0600	12	4	91	23	5	9	B			100	11			.0275	128	R
	4B	0600	12	4	91	23	5	9	B			100	10			.0158	131	R
	4C	0600	12	4	90	24	5	9	B			100	17			.0375	169	R
48	2A	0600	12	6	9[illegible]	20	5	13	B	100	23					.0058	47	O
	2B	0600	12	6	97	20	5	13	B			100	31			.0075	46	O
	2C	0600	12	6	97	20	5	13	B	65	10	35	18			.0142	62	O
	2D	0600	12	6	96	21	5	11	B	45	23	55	18			.0150	87	O
	2E	0600	12	6	96	21	5	11	B	60	14			40		.0183	139	O
50	5A	0600	12	5	80	28	60	7	BT	100	35					.0225	64	H
	5B	0600	12	5	83	27	60	8	B	75	29	25	25			.0675	32	H
	5C	0600	12	5	83	27	60	8	B			65	30	35		.0167	44	H
	5D	0600	12	5	81	28	60	7	B			55	29	45		.0358	67	H
	5E	0600	12	5	78	29	60	7	B	55	29	10	15	35		.0350	119	H
	6A	1800	12	0	52	47	70	4	BT	60	34			40		.0125		O
	6B	1800	12	0	52	47	70	4	BT	45	30			55		.0116		O
	6C	1800	12	0	52	47	70	4	B	45	32	55	32			.0092		O
51	2A	1800	12	0	62	34	6.5	5	T	100	11					[illegible]		[illegible]
	2B	1800	12	0	62	34	6.5	5	T					100		.0082		F
	3A	0600	12	6	83	14	4.0	18	T			45	31	55		.0184	95	F
	3B	0600	12	6	81	15	40	18	T	70	27			30		.0283	37	H
	4A	1800	12	5	59	37	60	7	T	65	24			35		.0266	86	O
	4[illegible]	1800	12	5	59	37	60	7	T	80	25			20		.0285	54	O
52	2A	1800	12	0	62	34	6.5	5	T	7[illegible]	15	30	15			.0067		O
	2B	1800	[illegible]	0	62	34	6.5	5	[illegible]			40	11	60		.2167		O
	2C	1800	12	0	62	34	6.5	5	[illegible]			100	15			.2083		O

GROUP [illegible] — 12-Hour Periods

FIRE				WEATHER					FUEL	TOPOGRAPHY: SLOPE UP		SLOPE DOWN				SPEED		
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI		%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
52	2D	1800	12	0	62	34	6.5	5	T			100	39			.0133		O
	2E	1800	12	0	62	34	6.5	5	T			55	27	45		.0083		O
	2F	1800	12	0	62	34	6.5	5	T					100		.0050		O
	3A	0600	12	6	86	13	4.0	18	T	65	22	35	15			.0127	126	O
	3B	0600	12	6	82	14	4.0	18	T			100	27			.0133	21	O
	3C	0600	12	6	81	15	4.0	18	T			55	37	45		.0200	93	O
	3D	0600	12	6	78	16	4.0	16	T			55	15	45		.0266	22	O
	3E	0600	12	6	79	15	4.0	18	T					100		.0100	75	O
	3F	0600	12	6	86	13	4.0	18	T			100	27			.0500	62	O
	4A	1800	12	5	59	37	6.0	7	T			100	22			.0083	8	O
	4B	1800	12	5	59	37	6.0	7	T	100	37					.0050	50	O
	4C	1800	12	5	59	37	6.0	7	T			60	37	25		.0165	92	O
	4D	1800	12	5	59	37	6.0	7	T			15	16	80		.0133	151	O
	4E	1800	12	5	59	37	6.0	7	B			100	30			.0033	142	R
	4F	1800	12	5	59	37	6.0	7	B	100	11					.0033	48	H
	5A	0600	12	11	73	22	4.0	23	T			100	30			.0133	163	R
	5B	0600	12	11	79	19	4.0	26	T			100	19			.0167	148	R
	5C	0600	12	11	82	18	4.0	26	B	60	18	40	25			.0133	89	O
	5D	0600	12	11	81	19	4.0	26	T			100	11			.0133	52	O
	5E	0600	12	11	76	21	4.0	23	T					100		.0050	58	O
	6A	1800	12	[illegible]	60	48	5.0	6	T			100	23			.0241	25	O
	7A	0600	12	3	97	14	3.0	14	B			45	18	[illegible]		.0584	28	O
53	2A	0600	12	5	80	20	5.0	11	B			100	19			.0274	46	O
	2B	0600	12	5	81	20	5.0	11	B			100	11			.0186	54	O
	2C	0600	12	5	81	20	5.0	11	B	20	19	50	20	30		.0396	84	O
	2D	0600	12	5	79	20	5.0	11	H					100		.0211	117	O
	4A	1800	12	9	65	38	6.5	10	GBH	75	23	25	11			.0412	75	[illegible]
	4B	1800	12	8	65	38	6.5	10	H			46	14	55		.0610	[illegible]	H
	4C	1800	12	9	65	38	6.5	10	H	30	12	70	28			.0542	1	H
	4D	1800	12	8	65	38	6.5	10	H			60	15	40		.0389	29	H
	5A	0600	12	4	70	32	5.0	8	HB	50	25	35	17	5		.0300	25	H
	5B	0600	12	4	72	31	[illegible]	8	B	35	29	65	19			.0315	25	H
	5C	0600	12	4	73	[illegible]	5.0	8	H	25	25	75	24			.0274	[illegible]	H
	5D	0600	12	4	71	32	5.0	8	[illegible]			100	16			.0090	23	H
	5E	[illegible]	12	4	75	30	5.0	8	[illegible]			70	25	[illegible]		.0137	8	H

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Perc. Flat	Sketch	Rate	Angle to Wind	Type
53	6A	1800	12	2	63	45	70	4	BH	25	27	75	22			.0147	21	H
	6B	1800	12	2	63	45	10	4	H			70	20	30		0200	18	H
	6C	1800	12	2	63	45	70	4	B			100	28			0143	1	H
	6D	1800	12	2	63	45	70	4	B[illegible]	30	22	70	24			.0174	29	H
	6E	1800	12	2	63	45	70	4	BH			100	22			0047	76	F
	6F	1800	12	2	63	45	70	4	H			100	[illegible]			.0089	105	F
	7A	0600	12	2	78	28	5.5	17	B	100	26					.0306	65	H
	7B	0600	12	12	80	26	55	19	B	100	13					.0137	93	H
	7C	0600	12	12	81	26	55	19	H	75	21	25	31			.0116	109	H
	7D	0600	12	12	80	27	55	19	B			100	12			0179	123	H
	7E	0600	12	12	82	26	55	19	BH			100	13			0353	145	R
	8A	1800	12	25	68	41	65	38	B	75	26			25		.0179	156	H
	8B	1800	12	25	68	41	65	38	BH			55	31	45		0189	155	H
	8C	1800	12	25	68	41	65	38	B			100	36			0131	166	R
	8D	1800	12	25	68	41	65	38	H			50	24	50		.0406	88	O
	8E	1800	12	25	68	41	65	38	H			100	17			.0605	89	O
	8F	1800	12	25	68	41	65	38	BH	20	15	80	15			.0964	25	O
	8G	1800	12	25	68	41	65	38	H			100	19			0726	12	O
	8H	1800	12	25	68	41	65	38	H			100	16			0358	14	O
	8I	1800	12	25	68	41	65	38	H	55	10	45	10			.0226	57	O
	8J	1800	12	25	68	41	65	38	H	75	12	25	15			0289	106	O
54	4A	0600	12	3	93	20	40	12	B					100		.0110	31	O
	4B	0600	12	3	94	19	4.0	12	H			100	15			.0047	1	O
	4C	0600	12	3	88	21	40	12	B			100	13			.0142	86	O
	4D	0600	12	3	92	20	40	12	H	100	17					.0095	6	H
	4E	0600	12	3	90	21	40	12	H	35	15	35	22	30		0158	17	O
	4F	0600	12	3	91	20	4.0	12	B			100	20			.0237	31	O
	4G	0600	12	3	90	21	40	12	B			55	40	45		.0205	[illegible]	O
	4H	0600	12	3	88	22	40	12	B			100	25			.0095	95	O
	5A	1800	12	0	71	39	4.5	7	B			100	7			.0120		O
	5B	1800	12	0	71	39	45	7	H			100	22			.0110		O
	5C	1800	12	0	71	39	45	7	B					100		0047		O
	5D	1800	12	0	71	39	45	7	B			100	22			.0095		O
	6A	0600	12	0	86	24	30	11	[illegible]	40	24	60	2			0458		H
	6B	0600	12	[illegible]	85	25	30	11	H	100	14					.0269		H

GROU[illegible] 12-[illegible]our Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
54	6C	0600	12	0	87	24	30	11	H	100	19					.0411		H
	6D	0600	12	0	86	24	30	11	H	100	21					.0316		H
59	2A	1800	12	2	69	38	55	7	T					100		.0050	94	O
	2B	1800	12	2	69	38	55	7	T	100	16					.0050	45	H
	[illegible]	1800	12	2	69	38	55	7	T	100	8					.0100	39	H
	2D	1800	12	2	69	38	55	7	T	100	13					.0167	10	H
	5A	1800	12	20	65	25	45	53	T	15	26	20	20	55		.0567	2	O
	5B	1800	12	20	65	25	45	53	T			65	14	35		.0400	2	O
	5C	1800	12	20	65	25	45	53	T	30	8			70		.0383	7	O
	5D	1800	12	20	65	25	45	53	T			75	13	25		.0317	43	O
	5E	1800	12	20	65	25	45	53	T			70	13	30		.0650	47	O
	5F	1800	12	20	65	25	45	53	T			75	20	25		.0916	28	O
	5G	1800	12	20	65	25	45	53	T			70	14	30		.0783	46	O
	5H	1800	12	20	65	25	45	53	T	75	8	25	13			.0183	145	O
	5I	1800	12	20	65	25	45	53	T			45	11	55		.0200	130	O
	5J	1800	12	20	65	25	45	53	T	35	14			65		.0183	180	O
	6A	0600	12	17	81	24	4.5	38	T					100		.0650	150	O
	6B	0600	12	17	83	23	45	38	T					100		.0668	129	O
	6C	0600	12	17	84	22	45	38	T	15	34	85	18			.0384	58	O
	6D	0600	12	17	85	22	4.5	38	T	15	20	30	18	55		.0500	45	O
	6E	0600	12	17	86	21	45	38	T	15	22	60	21	25		.0533	29	O
	6F	0600	12	17	85	22	45	38	T			100	10			.0383	42	O
	6G	0600	12	17	83	23	45	38	T			85	17	15		.0700	9	O
	6H	0600	12	17	82	23	45	38	T	15	10	85	17			.0683	9	O
	6I	0600	12	17	84	22	4.5	38	T			50	22	50		.0650	38	O
	6J	0600	12	17	85	23	45	38	T			70	11	30		.0450	50	O
	6K	0600	12	17	86	22	45	38	T			20	18	80		.0268	4[illegible]	[illegible]
	6L	0600	12	17	85	22	4[illegible]	3[illegible]	T			100	18			.0300	28	O
	6M	0600	12	17	84	23	45	38	T			100	17			.0250	50	O
	7A	1800	12	3	62	50	65	6	T			100	15			.0050	95	O
	7B	1800	12	3	62	50	65	6	T			100	18			.0100	92	O
	7C	1800	12	3	62	50	65	6	T	100	10					.0670	116	O
	7D	1800	12	3	62	50	65	6	T					100		.0050	113	O
	7E	1800	17	3	62	50	6.5	6	[illegible]					100		.0033	113	O
	7F	18[illegible]	12	3	62	50	65	6	T			100	17			.0150	13	O

GROUP [illegible] -Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
59	7G	1800	12	3	62	50	65	6	T			100	12			0133	22	O
	7H	1800	12	3	62	50	65	6	T			100	18			0150	34	O
	7I	1800	12	3	62	50	65	6	T					100		.0083	61	O
	7J	1800	12	3	62	50	65	6	T					100		0068	44	O
	7K	1800	12	3	62	50	65	6	T			100	11			.0159	26	O
	7L	1800	12	3	62	50	65	6	T	25	27			75		.0133	5	O
	7M	1800	12	3	62	50	65	6	T					100		.0281	24	O
	7N	1800	12	3	62	50	65	6	T			100	18			.0100	36	O
	7O	1800	12	3	62	50	65	6	T			100	10			0100	7	O
	7P	1800	12	3	62	50	6.5	6	T			100	14			.0083	11	O
	7Q	1800	12	3	62	50	65	6	T			100	16			.0010	4	O
	7R	1800	12	3	62	50	65	6	T			100	14			.0100	13	O
	7S	1800	12	3	62	50	65	6	T			100	14			.0167	24	O
60	2A	1800	12	2	62	46	7.0	4	BT	40	22			60		.0158	20	O
	2B	1800	12	2	62	46	7	4	BT	100	15					.0170	5	H
	2C	1800	12	2	62	46	7	4	BT	100	19					.0222	64	O
	6A	1800	12	16	59	33	5.5	24	T	35	10	25	10	40		.0554	39	H
	6B	1800	12	16	59	33	5.5	24	T	25	25			75		0555	30	H
	6C	1800	12	16	59	33	55	24	T	55	13			45		.0615	18	H
	6D	1800	12	16	59	33	5.5	24	T	35	13	65	22			0916	14	H
	6E	1800	12	16	59	33	55	24	T	45	13	45	18	[illegible]		.1679	0	H
	6F	1800	12	16	59	33	55	24	T	40	15	100	[illegible]			.2462	10	H
	6G	1800	12	16	59	33	55	24	T	25	19	45	23	30		.1990	23	H
	6H	1800	12	16	59	33	55	24	T	20	17	45	21	35		.1911	30	H
	6I	1800	12	16	59	33	55	24	T	25	21	35	17	40		.2210	30	H
	6J	1800	12	16	59	33	55	24	T	35	18	25	22	40		.1780	42	H
	6K	1800	12	16	59	33	55	24	T			45	20	55		.1290	55	H
	7A	0600	12	5	74	33	6	8	T	45	14	30	30	25		0815	3	H
	7B	0600	12	5	77	32	6	8	T	25	23	75	19			0865	0	H
	7C	0600	12	5	77	32	6	8	T	70	17			30		.0832	18	H
	7D	0600	12	5	80	30	6	8	T	35	17	10	25	[illegible]		.0815	27	H
	7E	0600	12	5	82	29	6	8	T	30	13	40	18	30		.0620	50	H
	7F	0600	12	5	83	[illegible]	6	8	T	10	18	30	22	60		.0525	75	H
	7G	0600	12	5	84	29	6	8	T	35	19	65	16			.0750	73	H
	8A	1600	12	3	55	62	7	4	T	100	24					.0244	45	H

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						[illegible]		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	Rh	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
60	8B	1800	12	3	55	62	7	4	T	100	14					.0278	28	H
	8C	1800	12	3	55	62	7	4	T			65	22	35		.0167	65	O
	8D	1800	12	3	55	62	7	4	T	100	9					.0100	78	O
	8E	1800	12	3	55	[illegible]	[illegible]	4	T			100	8			.0131	42	O
	8F	1800	12	3	55	62	7	4	T			20	13	80		.0229	42	O
61	2A	1900	12	3	59	59	8.5	4	T					100		.0067	145	O
	2B	1900	12	3	59	59	8.5	4	T	100	18					.0050	58	O
	2C	1900	12	3	59	59	8.5	4	T					100		.0083	32	O
	2D	1900	12	3	59	59	8.5	4	T	25	14	75	11			.0133	3	H
	2E	1900	12	3	59	59	8.5	4	T					100		.0050	78	O
	2F	1900	12	3	59	59	8.5	4	T	100	14					.0033	145	O
	2G	1900	12	3	59	59	8.5	4	T	100	14					.0067	130	O
	3A	0700	12	6	82	27	7	10	T	100	19					.0180	39	H
	3B	0700	12	6	82	27	7	10	T	65	14	35	14			.0200	20	H
	3C	0700	12	6	84	26	7	10	T	100	12					.0217	12	H
	3D	0700	12	6	84	26	7	10	T					100		.0100	175	H
	3E	0700	12	6	84	26	7	10	T	50	9	50	9			.0167	162	H
	3F	0700	12	6	83	[illegible]	7	10	T	100	9					.0150	135	H
	3G	0700	12	6	83	[illegible]	7	10	T	100	13					.0150	72	H
	4A	1900	12	2	62	48	8	5	T	100	6					.0083	132	H
	4B	1900	12	2	62	48	8	5	T					100		.0067	160	H
	4C	1900	12	2	62	48	8	5	T					100		.0100	178	H
	4D	1900	12	2	62	48	8	5	T	100	5					.0100	144	H
	4E	1900	12	2	62	48	8	5	T	100	26					.0067	100	H
	4F	1900	12	2	62	48	8	5	T	100	10					.0100	97	H
	5A	0700	12	12	86	21	[illegible]	19	T			65	11	35		.0216	57	H
	5B	0700	12	12	85	21	6	19	T			100	17			.0160	[illegible]	H
	5C	0700	12	12	84	22	6	19	T	100	10					[illegible]	[illegible]	[illegible]
	5D	0700	12	12	84	22	6	19	T	70	17			30		.0136	170	F
62	2A	1800	12	[illegible]	54	54	50	4	BT			100	10			.0183	8	O
	2B	1800	12	3	54	54	50	4	BT	30	10			70		.0200	12	O
	2C	1800	12	3	54	54	50	4	BT			100	10			.0167	43	O
	2D	1800	12	3	54	54	50	4	BT			100	11			.0083	154	R
	2E	1800	12	3	54	54	50	4	BT					100		.0083	151	O
	2F	1800	12		54	54	50	4	BT					100		.0083	179	O

GROUP [illegible] ur Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
68	4A	1800	12	10	56	37	4 5	18	T	35	17			65		.0667	5	H
	4B	1800	12	10	56	37	45	18	TG	50	22	50	5			.0700	7	H
69	2A	1500	12	4	56	41	45	10	B					100		.0450	56	H
	2B	1500	12	4	56	41	45	10	B					100		.0416	53	H
	2C	1500	12	4	56	41	45	10	B					100		.0367	48	H
	3A	0300	12	10	84	14	3.5	25	B					100		.0766	51	H
	3B	0300	12	10	84	14	35	25	B					100		.1070	40	H
	4A	1500	12	10	62	30	4	18	B					100		.1010	20	H
	4B	1500	12	10	62	30	4	18	B					100		.1667	18	H
	4C	1500	12	10	62	30	4	18	B					100		.1766	10	H
	4D	1500	12	10	62	30	4	18	B					100		.1800	3	H
	4E	1500	12	10	62	30	4	18	B					100		.1820	12	H
	4F	1500	12	10	62	30	4	18	B					100		.1768	16	H
	4G	1500	12	10	62	30	4	18	B					100		.1300	26	H
70	1A	0800	12	14	66	50	10	12	T	35	19			65		.0863	28	H
	1B	0800	12	14	67	49	10	12	T	60	20			40		.0487	24	H
	1C	0800	12	14	69	48	10	12	T	50	15			50		.0250	15	H
	1D	0800	12	14	70	48	10	12	T					100		.0063	40	F
	1E	0800	12	14	70	48	10	12	T					100		.0037	85	F
	1F	0800	12	14	70	48	10	12	T			100	24			.0050	144	R
	1G	0800	12	14	70	48	10	12	T					100		.0043	131	F
	1H	0800	12	14	69	48	10	12	T	40	11			[illegible]		.0175	49	H
	1I	0800	12	14	[illegible]	50	10	12	T	60	17			40		.0400	42	H
	1J	0800	12	14	67	49	10	12	T	50	17			50		.0600	33	H
71	2A	0600	12	17	83	67	8	12	BT					100		.8600	7	H
	2B	0600	12	17	83	67	8	12	BT					100		.8380	0	H
	3A	0600	12	10	81	54	9	6	BT					100		.3320	9	H
	3B	0600	12	10	81	54	9	6	BT					100		.2610	2	H
79	1A	1800	12	4	78	36	8	6	GB	100	10					.0167	125	F
	1B	1800	12	4	78	36	8	6	GB					100		.0167	175	R
	1C	1800	12	4	78	36	8	6	GB					100		.0200	133	R
	D	1800	12	4	78	36	8	6	GB	100	10					.0133	93	F
	1E	1800	12	4	78	36	8	6	GB	70	10			30		.0200	55	F
	1F	1800	[illegible]	4	78	36	8	6	GB	100	19					.0434	22	H
	1G	1800	12	4	78	36	8	6	GB	75	16			[illegible]5		.0366	17	H

GROUP II--12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Perc Flat	Sketch	Rate	Angle to Wind	Type
80	2A	0600	12	14	92	13	6	34	G	80	13	20	11			.0400	68	F
	2B	0600	12	14	92	13	6	34	G	100	80					.0317	63	F
	2C	0600	12	14	91	13	6	34	G	80	16			20		.0250	56	F
	2D	0600	12	14	91	12	6	34	G			100	27			.0167	66	F
	2E	0600	12	14	91	13	6	34	G			60	18	40		.0150	46	F
	2F	0600	12	14	93	13	6	34	G	40	14			60		.0067	8	F
	2G	0600	12	14	92	13	6	34	G					100		.0083	21	F
	2H	0600	12	14	91	13	6	34	G	40	23	60	11			.0366	24	F
	2I	0600	12	14	91	13	6	34	G	60	16					.0800	6	H
	2J	0600	12	14	88	13	6	34	G	80	19			20		.1469	7	H
	2K	0600	12	14	90	14	6	34	G	65	19	15	13	20		.1150	7	H
	2L	0600	12	14	90	14	6	34	G	80	17	10	22	10		.1050	8	H
	2M	0600	12	14	90	14	6	34	G	85	20	15	24			.0916	13	H
	2N	0600	12	14	92	13	6	34	G	50	17	30	20	20		.0634	18	H
	2O	0600	12	14	91	13	6	34	G	60	18			40		.0416	22	H
	2P	0600	12	14	90	14	6	34	G	50	16	50	16			.0250	60	F
	2Q	0600	12	14	91	13	6	34	G			100	20			.0067	91	F
	5A	1800	12	4	66	19	6	13	G	100	14					.0167	135	H
	5B	1800	12	4	66	19	6	13	G	100	15					.0217	150	H
	5C	1800	12	4	66	19	6	13	G	600	26					.0233	56	H
	5D	1800	12	4	66	19	6	13	G	70	24			30		.0284	63	H
81	3A	1900	12	3	49	40	8	6	TG					100		.0300	73	F
	3B	1900	12	3	49	40	8	6	TG					100		.0133	75	F
	3C	1900	12	3	49	40	8	6	TG					100		.0160	61	F
	3D	1900	12	3	49	40	8	6	TG					100		.0150	50	F
	3E	1900	12	3	49	40	8	6	TG					100		.0167	19	H
	3F	1900	12	3	49	40	8	6	TG					100		.0162	7	H
	3G	1900	12	3	49	40	8	6	TG					100		.0150	[illegible]	F
	5A	1900	12	3	49	40	8	6	TG					100		0700	73	H
	5B	1900	12	3	49	40	8	6	G					100		0550	74	H
	5C	1900	12	3	49	40	8	6	G					100		0600	79	H
	5D	1900	12	3	49	40	8	6	TG					100		0616	68	H
	5E	1900	12	3	49	40	8	6	G					100		0400	95	H
	5F	1900	12	3	49	40	8	6	G					100		0683	58	H
	5G	1900	12	3	49	40	8	6	G					100		0950	48	H

GROUP II 12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
81	5H	1900	12	3	49	40	8	6	G					100		.1350	32	H
	5I	1900	12	3	49	40	8	6	G					100		.0600	77	H
	5J	1900	12	3	49	40	8	6	TG					100		.1360	82	H
	5K	1900	12	3	49	40	8	6	TG					100		.1016	84	H
	5L	1900	12	3	49	40	8	6	TG					100		.0717	90	H
	5M	1900	12	3	49	40	8	6	TG					100		.0317	128	F
	5N	1900	12	3	49	40	8	6	TG					100		.0333	157	F
	6A	0700	12	12	54	42	8	12	TG					100		.0434	21	H
	6B	0700	12	12	54	42	8	12	G					100		.0384	21	H
	6C	0700	12	12	54	42	8	12	G					100		.0500	18	H
	6D	0700	12	12	54	42	8	12	G					100		.0318	20	H
	6E	0700	12	12	54	42	8	12	G					100		.0433	17	H
	6F	0700	12	12	64	42	8	12	G					100		.0332	21	H
	6G	0700	12	12	54	42	8	12	G					100		.0384	28	H
	6H	0700	12	12	54	42	8	12	TG					100		.0183	0	H
	6I	0700	12	12	64	42	8	12	TG					100		.0266	0	H
	6J	0700	12	12	54	42	8	12	TG					100		.0200	0	H
	6K	0700	12	12	54	42	8	12	TG					100		.0167	0	H
	6L	0700	12	12	54	42	8	12	TG					100		.0167	0	H
	6M	0700	12	12	64	42	8	12	TG					100		.0084	67	F
	6N	0700	12	10	54	42	8	12	G					100		.0217	10	H
	6O	0700	12	10	64	42	8	12	TG					[illegible]		.0300	152	H
	7A	1900	12	8	52	43	9	7	GB					100		.0150	30	H
	7B	1900	12	8	52	43	9	7	GB					100		.0167	35	H
	7C	1900	12	8	52	43	9	7	GB					100		.0260	22	H
	7D	1900	12	8	52	43	9	7	GB					100		.0160	58	H
	7E	1900	12	8	52	43	9	7	GB					100		.0250	20	H
	7F	1900	12	8	52	43	9	7	GB					100		.0200	30	H
	7G	1900	12	8	52	43	9	7	TG					100		.0165	31	H
	7H	1900	12	8	52	43	9	7	TG	20	10			80		.0167	31	H
	7I	1900	12	3	52	43	9	7	TG					00		.0184	31	H
	7J	1900	12	8	52	43	9	7	TG					100		.0184	45	H
	7K	1900	12	8	52	43	9	7	TG					100		.0200	45	H
	7L	1900	12	8	52	43	9	7	TG					100		.0150	45	H
	7M	1900	12	3	52	43	9	7	TG					[illegible]		.0167	45	H

GROUP II—12-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
81	7N	1900	12	8	52	43	9	7	G					100		0100	54	H
	7O	1900	12	8	52	43	9	7	G					100		0184	4	H
	7P	1900	12	8	52	43	9	7	TG					100		0416	37	H
	7Q	1900	12	8	52	43	9	7	GB					100		0200	29	H
	7R	1900	12	8	52	43	9	7	GB					100		.0200	9	H
[illegible]	1A	1900	12	14	59	37	7	39	TB					100		.1260	82	H
	1B	1900	12	19	59	37	7	39	TB					100		.1417	67	H
	1C	1900	12	19	59	37	7	39	TB					100		.2333	50	H
	1D	1900	12	19	59	37	7	39	TB					100		.5833	73	H
	1E	1900	12	19	59	37	7	39	TB					100		5260	65	H
	1F	1900	12	19	59	37	7	39	TB					100		5916	65	H
	1G	1900	12	19	59	37	7	39	TB					100		7000	60	H
	1H	1900	12	19	59	37	7	39	TB					100		6250	57	H
	1I	1900	12	19	59	37	7	39	TB					100		9250	57	H
	1J	1900	12	19	59	37	7	39	TB					100		8533	56	H
	1K	1900	12	19	59	37	7	39	TB					100		7250	55	H
	1L	1900	12	19	59	37	7	39	TB					100		.7917	53	H
	1M	1900	12	19	59	37	7	39	TB					100		1.017	53	H
	1N	1900	12	19	59	37	7	39	TB					100		1.083	53	H
	1O	1900	12	19	59	37	7	39	TB					100		1.117	48	H
	1P	1900	12	19	59	37	7	39	TB					100		1.042	48	H
	1Q	1900	12	19	59	37	7	39	TB					100		1.000	45	H
	1R	1900	12	19	59	37	7	39	TB					100		[illegible]	43	H
	1S	1900	12	19	59	37	7	39	TB					100		1.025	41	H
	1T	1900	12	19	59	37	7	39	TB					100		1.033	35	H
	1U	1900	12	19	59	37		39	TB					100		1.067	34	H
	1V	1900	12	19	59	37	7	39	TB					100		1.060	[illegible]	H
	1W	1900	12	19	59	37	7	39	TB					100		[illegible]	29	
	1X	1900	12	19	59	37	7	39	TB					100		1.092	25	H
	1Y	1900	12	19	59	37	7	39	TB					100		1.108	23	H
	1Z	1900	12	19	59	37	7	39	TB					100		1.100	22	H
93	2A	0600	12	11	94	13	45	25	B	30	34	45	24	[illegible]		.0602	41	H
	2B	0600	12	11	92	14	45	25	B	50	18	50	17			.0750	34	H
	2C	0600	12	11	92	14	45	25	B	70	17	30	13			.0902	30	H
	2D	0600	12	11	90	14	45	25	[illegible]	65	22	15	17	[illegible]		[illegible]	26	H

GROU[illegible] – [illegible]our Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
93	2E	0600	12	11	88	15	4 5	25	B	65	25			35		.0918	0	H
	2F	0600	12	11	91	14	4 5	25	B	35	17			65		.0367	10	H
	3A	1800	12	5	64	38	5.5	7	B			35	18	65		.0500	90	F
	3B	1800	12	5	64	38	5.5	7	B	45	19	40	22	15		.0746	88	F
	3C	1800	12	5	64	38	5.5	7	B	40	35	20	24	40		.0750	100	F
	4A	0600	12	8	87	18	5	15	B			1[illegible]	16			.0950	46	F
	4B	0600	12	8	87	18	5	15	B			70	15	30		.0800	40	F
	4C	0600	12	8	90	17	5	15	C			75	26	25		.0565	34	F
	4D	0600	12	8	90	17	5	15	B	25	24	75	22			.0400	31	F
	4E	0600	12	8	91	16	5	15	B	75	12	25	11			.0250	37	F
96	2A	1200	12	20	90	10	3 5	58	TB					100		.0336	1	H
	2B	1200	12	20	88	10	3.5	58	TB			35	25	65		.0333	20	H
	2C	1200	12	20	87	11	3.5	58	TB			100	25			.0359	34	H
	2D	1200	12	20	86	11	3.5	58	TB			70	35	30		.0433	49	H
100	2A	1800	12	12	76	18	4.5	25	B					100		.0160	101	F
	2B	1800	12	12	76	19	4 5	25	B	30	11	70	11			.0417	117	F
	2C	1800	12	12	77	17	4 5	25	B	25	18	20	19	55		.1260	114	H
	2D	1800	12	12	77	17	4 5	25	B	25	11	15	17	60		.1380	108	H
	2E	1800	12	12	77	17	4.5	25	B	25	10			75		.1550	105	H
	2F	1800	12	12	74	18	4.5	25	B	70	15			30		.1820	68	H
	2G	1800	12	12	75	16	4.5	25	B	55	14			45		1365	59	H
	2H	1800	12	12	77	16	4 5	25	B	60	14			[illegible]		.0868	64	H
	2I	1800	12	12	78	16	4 5	25	B			100	10			.0450	19	F
	2J	1800	12	12	78	16	4.5	26	B			100	10			0434	84	F
	2K	1800	12	12	79	15	4 5	25	B					100		.0417	106	F
	2L	1800	12	12	80	15	4.5	25	B					100		.0266	107	F
	2M	1800	12	12	80	15	4 5	25	B					100		.0367	117	F
	2N	1800	12	12	80	15	4 5	25	B					100		.0550	134	F
	2O	1800	12	12	79	15	4.5	25	B			100	7			.0733	139	H
	2P	1800	12	12	80	15	4.5	25	B	15	11	85	10			.1530	163	H
	2Q	1800	12	12	78	16	4.6	25	B			45	13	55		.2020	172	H
	3A	0600	12	13	92	17	4.0	27	B			70	16	30		.0618	116	F
	3B	0600	12	13	93	16	4 0	27	B	.30	9	30	10	40		5200	126	F
	3C	0600	[illegible]	13	93	16	4.0	27	B			25	18	75		.1230	127	F
	3D	0600	12	13	93	16	4.0	27	B			35	18	65		.1500	132	F

GROUP [illegible] ur Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
100	3E	0600	12	13	95	16	40	27	B	30	7	20	18	50		.2480	134	F
	3F	0600	12	13	96	15	4.0	27	B	15	10	40	16	45		.2720	135	H
	3G	0600	12	13	97	15	4.0	27	B	25	9	30	10	45		.5090	134	F
	3H	0600	12	13	96	15	40	27	B			20	12	80		.5200	138	H
	3I	0600	12	13	97	15	40	27	B			30	14	70		.5600	140	H
	3J	0600	12	13	97	15	40	27	B			25	13	75		.5790	141	H
	3K	0600	12	13	97	15	4.0	27	B			30	13	70		.7990	144	H
	3L	0600	12	13	95	16	40	27	B			10	7	90		.9190	145	H
	3M	0600	12	13	96	15	40	27	B			10	8	90		.8790	148	H
	3N	0600	12	13	95	16	4.0	27	B			10	6	90		.6640	150	H
	3O	0600	12	13	95	16	40	27	B	10	14	10	9	80		.6390	164	H
	3P	0600	12	13	95	16	40	27	B	10	23	10	8	80		.6420	157	H
	3Q	0600	12	13	95	15	40	27	B	20	90	10	9	70		.6210	162	H
	3R	0600	12	13	98	14	4.0	27	B	10	8	10	8	80		.5590	163	H
	3S	0600	12	13	96	15	40	27	B	20		10	9	70		.5172	165	H
	3T	0600	12	13	99	14	40	27	B			10	10	90		.4080	166	H
	3U	0600	12	13	98	15	4.0	27	B	10	25			90		.3980	172	H
	3V	0600	12	13	98	15	40	27	B	10	14			90		.3860	180	H
	3W	0600	12	13	98	15	4.0	27	B	20	9			80		.3850	177	H
	3X	0600	12	13	100	14	40	27	B	20	10	25	9	55		.3900	177	H
	3Y	0600	12	13	101	13	40	27	B	10	14	35	8	55		.2935	175	H
	3Z	0600	12	13	101	13	40	27	B	10	14	10	13	85		1800	169	H
	3AA	0600	12	13	102	13	40	27	B					100		.1380	179	H
	3BB	0600	12	13	104	12	40	27	B					100		.1080	171	H

GROUP III—13-23-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel	Temp.	RH	Stick	BI	FUEL	%	Aver Deg	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
1	1A	1630	13½	3	69	33	60	8	GHB	65	20	25	3	10		.1332	179	H
	1B	1630	13½	3	69	33	60	8	GH	65	18			35		1300	156	H
	1C	1630	13½	3	69	33	60	8	GH	55	21	45	15			.1042	120	H
	1D	1630	13½	3	69	33	60	8	GH	65	30	35	22			0625	80	F
4	5A	1700	13	5	783	117	14	19	B	25	16	45	17	30		0516	22	H
	5B	1700	13	5	761	116	1.4	19	B	55	19	45	24			0302	3	O
	5C	1700	13	5	735	126	14	19	B	60	11	40	14			.0198	38	O
	5D	1700	13	5	692	143	14	19	B			100	25			0127	19	O
	5E	1700	13	5	661	158	14	19	B	100	10					0079	116	O
	5F	1700	13	5	699	140	14	19	B	30	29	70	33			0302	160	R
	5G	1700	13	5	705	138	14	19	B	20	38	80	32			0421	140	R
	6A	0600	13	5	834	153	12	19	TB	100	23					0381	37	H
	6B	0600	13	5	835	152	12	19	B	76	24			25		0476	60	F
	6C	0600	13	5	872	137	12	19	TB			100	20			.0159	160	R
	6D	0600	13	5	867	139	12	17	TB	60	15			40		.0635	126	O
	6E	0600	13	5	885	132	12	19	TB					100		0635	119	O
	7A	1900	13	2	632	207	11	13	B			90	29			0254	0	O
	7B	1900	13	2	677	189	11	13	B	80	29	20	37			0207	64	O
	7C	1900	13	2	696	182	11	13	TB	75	23			25		0277	73	O
	7D	1900	13	2	717	173	11	13	B	80	31					0119	159	O
	7E	1900	13	2	723	171	11	13	TB	50	30	25	11	25		0223	133	O
	7F	1900	13	2	691	184	11	13	TB			100	33			0103	122	O
	7G	1900	13	2	755	158	11	13	TB			100	15			0103	100	O
	7H	1900	13	2	662	195	11	13	TB	100	27					0119	80	O
	9A	1800	22	2	65.	224	11	13	TB	70	21	30	11			1333	168	H
18	1A	1600	14	12	78	56	5	10	B	100	10					.0218	99	H
45	1A	0925	19	8	88	26	5	14	BT	100	27					.0688	13	H
47	1A	1345	16¼	8	100	16	4.5	18	B	35	13	20	10	45		.0945	11	[illegible]
	1B	1345	16¼	8	100	16	4.5	18	B	45	10			55		.1322	10	H
	1C	1345	16¼	8	100	16	4.5	18	B	45	8	45	10	10		.1286	26	H
	1D	1345	16¼	8	100	16	4.5	18	B	45	11	45	7	10		0909	47	H
	1E	1345	16¼	8	99	17	4.5	18	B	20	31	25	12	25		0903	72	H
48	1A	1345	16¼	8	100	16	4.5	18	B			75	21	25		0130	9	O
	1B	1345	16¼	8	101	16	4.5	18	B			100	14			.0213	78	O
	1C	1345	16¼	8	99	17	4.5	18	[illegible]			80	10	20		0198	136	R

GROUP III—13-23-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
48	1D	1345	16¼	8	99	17	4.5	18	B	50	18	50	12			.0192	177	O
	1E	1345	16¼	8	99	17	4.5	18	B	35	22			65		.0105	112	O
49	3A	1800	14	4	62	37	6.0	7	B	20	14			80		.0361	62	O
	3B	1800	14	4	62	37	6.0	7	B	50	21	40	13	10		.1108	109	H
	3C	1800	14	4	62	37	6.0	7	B	100	16					.0250	175	O
	5A	1800	14	5	59	43	6	5	BT			30	17	70		.0606	120	H
	5B	1800	14	5	59	43	6	5	BT			80	13	20		.0572	71	H
	5C	1800	14	5	59	43	6	5	BT	100	5					.0588	12	H
	5E	1800	14	5	59	43	6	5	BT	70	27			30		.0446	71	R
	5F	1800	14	5	59	43	6	5	BT	60	25			40		.0446	68	R
	5G	1800	14	5	59	43	6	5	BT	100	8					.0411	102	R
	7A	1800	14	2	63	47	6.5	4	BT	50	15			50		.0500	121	H
	7B	1800	14	2	63	47	6.5	4	BT	100	16					.0470	50	R
51	1A	0200	16	7	85	14	6.0	12	B	60	25			40		.0650	41	H
	1B	0200	16	7	86	14	6.0	12	B	75	21	10	19	15		.0625	23	H
	1C	0200	16	7	88	13	6.0	12	B	70	21			30		.0350	1	H
52	1A	0200	16	7	83	15	6.0	12	B	75	23	25	26			.0418	3	H
	1B	0200	16	7	83	15	6.0	12	B	65	25	35	10			.0400	31	H
	1C	0200	16	7	83	15	6.0	12	B	100	23					.0234	80	F
	1D	0200	16	7	84	14	6.0	12	B	45	11	55	11			.0112	126	F
	1E	0200	16	7	85	14	6.0	12	B			100	15			.0060	174	R
	1F	0200	16	7	85	14	6.0	12	B			100	26			.0663	81	F
67	2A	1400	20	6	72	32	6	9	B			100	2[illegible]			[illegible]	18	O
	2B	1400	20	6	72	32	6	9	B			50	14	50		.0083	81	O
71	1A	1100	15	10	80	50	6.5	5	BT					100		.7240	10	H
	1B	1100	15	10	80	50	6.5	5	BT					100		.6660	14	H
	1C	1100	15	10	80	50	6.5	5	BT					100		.4250	[illegible]	H
	1D	1100	15	10	80	50	6.5	5	BT					00		.3950	25	
	1E	1100	15	10	80	50	6.5	5	BT					100		.3730	30	H
	2C	0600	18	[illegible]	83	67	8	12	BT					100		.3550	3	H
	2D	0600	18	17	83	67	8	12	BT					100		.4080	8	H
	2E	0600	18	17	83	67	8	12	BT					100		.3330	16	H
73	1A	0000	18	10	68	46	10	8	BT					100		.0146	68	O
	1B	0000	18	10	68	46	10	8	BT					100		.0407	15	O
	1C	0000	18	[illegible]	68	46	10	8	BT					100		.0098	45	O

GROUP III—13-23-Hour Periods

FIRE				WEATHER					FUEL	TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
73	2A	2100	23	12	75	56	12	5	T					100		.0589	90	O
	2B	2100	23	12	75	56	12	5	T					100		.0511	90	O
74	2A	0600	13	11	88	32	6	14	BT					100		.0192	39	F
	2B	0600	13	11	88	32	6	14	BT					100		.0320	33	F
	2C	0600	13	11	88	32	6	14	BT					100		.0384	31	F
	2D	0600	13	11	88	32	6	14	BT					100		.0961	32	H
	2E	0600	13	11	88	32	6	14	BT					100		.1476	8	H
	2F	0600	13	11	88	32	6	14	BT					100		.0320	80	F
	2G	0600	13	11	88	32	6	14	BT					100		.0384	75	F
	2H	0600	13	11	88	32	6	14	BT					100		.1152	61	H
83	2A	2100	19	8	63	15	4	23	B			25	20	75		.0561	14	F
	2B	2100	19	8	64	14	4	23	B	30	10	40	20	30		.0740	17	F
	2C	2100	19	8	64	14	4	23	B	25	13	55	13	20		.0819	10	F
	2D	2100	19	8	63	14	4	23	B			20	15	80		.0941	18	F
	2E	2100	19	8	62	15	4	23	B	20	15	35	12	45		.1019	22	F
	2F	2100	19	8	62	15	4	23	B	10	[illegible]	20	10	70		.1075	30	F
	2G	2100	19	8	62	15	4	23	B			10	10	90		.1075	27	F
85	4A	1600	14	9	59	32	5.5	9	T	25	12			75		.0773	20	H
	4B	1600	14	9	59	32	5.5	9	T					100		.0428	15	H
	4C	1600	14	9	59	32	5.5	9	T					100		.0228	34	H
	4D	1600	14	9	59	32	5.5	9	T	100	14					.0186	33	H
	4E	1600	14	9	59	32	5.5	9	T					100		.0300	30	H
	5A	0600	15	18	69	29	5.5	26	T					100		.0413	15	H
	5B	0600	15	18	69	29	5.5	26	T			100	12			.0293	52	H
	5C	0600	15	18	69	29	5.5	26	T					100		.0668	37	H
	5D	0600	15	18	69	29	5.5	26	T					100		.1025	22	H
	5E	0600	15	18	69	29	5.5	26	T					100		.1012	19	H
89	2A	1500	17	4	74	51	6.5	5	B	75	22	25	23			.0258	165	[illegible]
	2B	1500	17	4	74	51	6.5	5	B					100		.0247	161	F
	2C	1500	17	4	74	51	6.5	5	B	100	7					.0223	169	F
	2D	1500	17	4	74	51	6.5	5	B	80	20			20		.0282	163	F
	2E	1500	17	4	74	51	6.5	5	B	25	30			70		.0224	120	F
	2F	1500	17	4	74	51	6.5	5	B	100	17					.0176	111	F
	2G	1500	17	4	74	51	6.5	5	B	25	13			75		.0423	105	H
	2H	1500	[illegible]	[illegible]	74	51	6.5	5	B	60	24			40		.0353	10	H

GROUP I[illegible] -13 23-Hour Periods

FIRE				WEATHER					FUEL	TOPOGRAPHY: SLOPE UP		SLOPE DOWN				SPREAD		
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI		%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
89	2I	1500	17	4	74	51	6.5	5	B	100	18					.0587	5	H
	2J	1500	17	4	74	51	6.5	5	B	65	22			35		.0458	1	H
	2K	1500	17	4	74	51	6.5	5	B	60	22			40		.0400	9	H
	2L	1500	17	4	74	51	6.5	5	B	100	18					.0259	16	H
	2M	1500	17	4	74	51	6.5	5	B					100		.0247	44	H
92	1A	1730	14.5	28	80	6	3.5	84	B	25	17	60	12	15		.0962	35	H
	1B	1730	14.5	28	78	7	3.5	84	B	50	19	50	17			.0989	46	H
	1C	1730	14.5	28	78	7	3.5	84	B	40	17	60	16			.0910	58	H
	1D	1730	14.5	28	79	6	3.5	84	B	20	17	80	22			.0372	66	F
	1E	1730	14.5	28	79	7	3.5	84	B			100	18			.0248	166	R
	1F	1730	14.5	28	80	6	3.5	84	B			100	19			.0345	153	R
94	1A	1100	19	3	96	20	4.5	12	T	50	12	15	14	35		.1662	35	H
	1B	1100	19	3	95	21	4.5	12	T	60	13			40		.1484	26	H
	1C	1100	19	3	96	2[illegible]	4.5	12	T	55	13	15	9	30		.1148	18	H
	1D	1100	19	3	96	20	4.5	12	T	60	10	40	8			.0875	13	H
	1E	1100	19	3	95	21	4.6	12	T	45	21			55		.0589	6	H
97	1F	[illegible]30	20½	23	89	23	8	39	TB					100		.4229	35	H
	1G	1230	20½	23	89	23	8	39	TB					100		.4229	36	H
	1H	1230	20½	23	89	23	8	39	TB					100		.4200	37	H
	1I	1230	20½	23	89	23	8	39	TB					100		.8868	37	H
	1J	1230	20½	23	89	23	8	39	TB					100		.3544	35	H
	1K	1230	20½	23	89	23	8	39	TB					100		.3610	37	H
	1L	1230	20½	2[illegible]	89	23	8	39	TB					100		[illegible]	38	[illegible]
	1M	1230	20½	23	89	23	[illegible]	3[illegible]	TB					100		.3618	39	H
	1N	1230	20½	23	89	23	8	39	TB					100		.3667	39	H
	1O	1230	20½	23	89	23	[illegible]	39	TB					100		.3610	40	H
	1P	1230	20½	23	89	23	8	39	TB					100		.3496	[illegible]	H
	1Q	1230	20½	23	89	23	8	39	TB					100		[illegible]	41	
	1R	1230	20½	23	89	23	8	39	TB					100		.3463	41	H
	1S	1230	20½	23	89	23	8	39	TB					100		.3284	42	H
	1T	1230	20½	23	89	23	8	39	TB					100		.3203	43	H
	1U	1230	20½	23	89	23	8	39	TB					[illegible]		.3122	44	H
98	1A	1100	21	18	85	40	8	18	B					100		.3238	12	H
	1B	1100	21	18	86	40	8	18	B					100		.2953	5	H
	1C	1100	21	8	[illegible]5	40	[illegible]	18	B					100		[illegible]	1	H

GROUP III—13-23-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPEED		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	Fuel	%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
98	1D	1100	21	18	85	40	8	18	B					100		.2176	16	H
102	1A	1300	21	12	75	65	10.5	6	B					100		.0428	58	F
	1B	1300	21	12	75	65	10.5	6	B					100		.0667	76	F
	1C	1300	21	12	75	65	10.5	6	B					100		.0714	86	F
	1D	1300	21	12	75	65	10.5	6	B					100		.0192	98	F
	1E	1300	21	12	75	65	10.5	6	B					100		.0190	129	F
	1F	1300	21	12	75	65	10.5	6	B					100		.0476	144	F
	1G	1300	21	12	75	65	10.5	6	B					100		.0572	58	F
	1H	1300	21	12	75	65	10.5	6	B					100		.0666	65	F
	1I	1300	21	12	75	65	10.5	6	B					100		.0476	106	F
	1J	1300	21	12	75	65	10.5	6	B					100		.0712	114	F
	1K	1300	21	12	75	65	10.5	6	B					100		.0761	123	F
	1L	1300	21	12	75	65	10.5	6	B					100		.0660	136	F
	1M	1300	21	12	75	65	10.5	6	B					100		.0618	118	F
	1N	1300	21	12	75	65	10.5	6	B					100		.0523	136	F
	1O	1300	21	12	75	65	10.5	6	B					100		.0523	149	F
	1P	1300	21	12	75	65	10.5	6	B					100		.0427	127	F
	1Q	1300	21	12	75	65	10.5	6	B					100		.0381	142	F
	1R	1300	21	12	75	65	10.5	6	B					100		.0381	172	F
	1S	1300	21	12	75	65	10.5	6	B					100		.0286	124	F
	1T	1300	21	12	75	65	10.5	6	B					100		.0283	150	F
	1U	1300	21	12	75	65	10.5	6	B					100		.0142	121	F
105	1A	1630	17.5	12	97	8	2.5	43	B	100	2[illegible]					.0160	139	R
	1B	1630	17.5	12	96	9	2.5	43	B	100	18					.0229	121	R
	1C	1630	17.5	12	96	9	2.5	43	B	35	14	35	8	30		.1985	5	R
	1D	1630	17.5	12	97	8	2.5	43	B	40	18	35	10	25		.1600	15	R
	1E	1630	17.5	12	96	9	2.5	43	B	50	16	30	16	20		.146[illegible]	20	R
	1F	1630	17.5	12	97	8	2.5	43	B	45	22	55	20			.1050	13	[illegible]
	1G	1630	17.5	12	98	8	2.5	43	B	45	17	55	20			.0358	56	R

GROUP IV—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Perc Flat	Sketch	Rate	Angle to Wind	Type
3	3A	0600	24	30	86	34	50	44	B	20	12			80		.1181	16	H
	3B	0600	24	30	86	34	50	44	B	10	10	10	11	80		.0907	4	H
	3C	0600	24	30	86	34	50	44	B			55	12	45		.0271	67	F
6	3A	0400	24	8	97	12	20	26	C	100	10					.0292	26	H
	3B	0400	24	7	8[illegible]	36	40	10	B	30	22	25	14	45		.0146	164	F
[illegible]	2A	0600	24	11	71	46	6	12	B	15	14	40	[illegible]	45		.0583	179	H
	3A	0600	24	10	84	37	5	13	B			100	27			.0042	52	O
	4A	0600	24	11	85	27	45	21	B			100	14			.0167	52	H
	4B	0600	24	11	83	26	4.5	21	B			100	22			.0125	74	H
	7A	0600	24	12	80	32	45	18	B			100	40			.0042	170	R
	12A	1800	24	9	78	36	6	9	B			75	17	25		.0167	124	H
53	3A	1800	24	8	76	28	5.5	16	H			35	21	65		.0395	11	O
	3B	1800	24	8	76	28	5.5	15	H	65	18	35	10			.0185	17	H
	3C	1800	24	8	75	29	55	11	HB			85	17	15		.0227	49	O
	3D	1800	24	8	79	27	5.5	15	B			100	22			.0226	65	O
55	2A	1000	24	19	85	8	30	55	B	50	13	20	17	30		.2108	0	H
	2B	1000	24	19	82	9	30	55	B	10	10	20	10	40		.1810	7	H
	2C	1000	24	19	83	9	30	55	B			35	10	65		.0635	56	H
	3A	1000	24	16	84	13	3.0	40	B	10	12			90		.2146	15	H
66	2A	0800	24	14	74	30	45	24	T	25	10	25	10	50		.0866	5	H
	2B	0800	24	14	74	30	45	24	T	50	12	25	12	25		.0841	2	H
	2C	0800	24	14	73	30	45	24	T	50	12	10	13	40		.0767	12	H
	2D	0800	24	14	72	30	45	24	T	65	13	10	26	25		.0750	21	H
	2E	0800	24	14	73	30	4.5	24	T	75	10	15	12	10		.0533	30	H
	2F	0800	24	14	74	30	4.5	24	T	45	10	25	10	30		.0416	33	H
	2G	0800	24	14	74	30	45	24	T			40	10	60		.0291	45	H
	2H	0800	24	14	74	30	45	24	T			60	12	40		.0233	50	H
	2I	0800	24	14	73	30	45	24	T					100		.0200	6[illegible]	[illegible]
	2J	0800	24	14	73	30	45	24	T	40	15			60		.0133	69	H
67	3A	1000	24	2	75	32	6	6	B	70	11	30	14			.0104	41	H
70	2A	2400	24	5	69	42	85	5	T					100		.0025	23	H
	2B	2400	24	5	68	43	8.5	5	T					100		.0029	1	H
	2C	2400	24	5	67	43	8.5	5	T					100		.0025	6	H
	2D	2400	24	5	66	44	8.5	5	T			100	12			.0058	101	R
	2E	2400	[illegible]	5	65	44	8.5	5	T			100	14			.0021	153	R

GROUP IV -24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
70	2F	2400	24	5	65	44	8.5	5	T					100		.0025	117	R
	2G	2400	24	5	64	44	8.5	5	T					100		.0021	160	R
	3A	2400	24	10	77	32	5.5	13	B	100	10					.0067	36	H
	3B	2400	24	10	75	33	5.5	13	B	60	12			40		.0083	38	H
	3C	2400	24	10	74	33	5.5	13	B					100		.0010	27	H
	4A	2400	24	8	77	20	5.5	13	T					100		.0025	121	F
	4B	2400	24	8	75	21	5.5	13	T	100	10					.0043	76	H
	4C	2400	24	8	74	21	5.5	13	T	100	10					.0050	79	H
	4D	2400	24	8	73	22	5.5	13	T	20	12			80		.0083	64	H
	4E	2400	24	8	72	22	5.5	13	B	100	17					.0150	43	H
	4F	2400	24	8	70	23	5.5	13	B					100		.0050	100	H
	4G	2400	24	8	70	23	5.5	13	B	100	10					.0058	67	H
	5A	2400	24	7	73	21	4.5	11	T			30	18	70		.0150	17	H
	5B	2400	24	7	72	22	4.5	11	T	55	11			45		.0117	23	H
	5C	2400	24	7	69	22	4.5	11	B					100		.0074	14	H
	5D	2400	24	7	69	22	4.5	11	T	100	11					.0125	15	H
	5E	2400	24	7	69	22	4.5	11	T	100	15					.0083	3	H
	5F	2400	24	7	69	22	4.5	11	T	100	15					.0050	12	H
71	2F	0600	24	17	83	67	8	12	BT					100		.1980	22	H
	2G	0600	24	17	83	67	8	12	BT					100		.1670	34	H
	2H	0600	24	17	83	67	8	12	BT					100		.1580	45	H
	2I	0600	24	17	83	67	8	12	BT					[illegible]		.1440	60	F
	3C	0600	24	10	81	54	9	6	BT					100		.1110	10	H
	3D	0600	24	10	81	54	9	6	BT					100		.0970	18	H
	3E	0600	24	10	81	54	9	6	BT					100		.0860	34	H
77	4A	2000	24	15	98	18	5	31	BG	100	18					.0050	66	R
	4B	2000	24	15	98	18	5	31	BG	100	22					.0050	167	[illegible]
	4C	2000	24	15	95	17	5	31	BG	100	31					.0050	165	R
	4D	2000	24	15	95	17	5	31	BG					100		.0050	161	R
	4E	2000	24	15	95	17	5	31	BG	100	11					.0040	158	R
	4F	2000	24	15	96	17	5	31	BG	25	27			[illegible]		.0067	140	R
	4G	2000	24	15	95	17	5	31	BG					100		.0033	133	R
	4H	2000	24	15	95	17	5	31	BG					100		.0017	133	R
	4I	2000	24	15	93	18	5	31	[illegible]					100		.0131	99	R
	4J	2000	[illegible]	15	93	18	5	31	[illegible]			25	10	75		.0250	92	R

GROUP IV—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
77	4K	2000	24	15	95	17	5	31	BG	80	10			20		.0534	101	F
	4L	2000	24	15	98	16	5	31	BG	30	18	30	20	40		.0616	90	F
	4M	2000	24	15	98	16	5	31	BG	10	25	20	25	70		.0684	90	F
	4N	2000	[illegible]4	15	103	14	5	31	BG	20	25	10	25	70		.0684	79	F
	4O	2000	24	15	105	13	5	31	BG	30	25	30	24	40		.0500	96	F
	4P	2000	24	16	105	13	5	31	BG	10	10	10	[illegible]	80		.0450	85	F
	4Q	2000	24	15	105	13	5	31	BG					100		.0416	88	F
	4R	2000	24	15	105	13	5	31	BG			50	10	50		.0466	84	F
	4S	2000	24	15	105	13	5	31	BG			50	10	50		.0500	71	F
	4T	2000	24	15	98	16	5	31	BG	60	14			40		.0133	80	F
	4U	2000	24	15	98	16	5	31	BG	100	16					.0165	79	F
	4V	2000	24	15	95	17	5	31	BG	100	14					.0165	87	F
	4W	2000	24	15	95	17	5	31	BG					100		.0064	107	F
	4X	2000	24	15	105	13	5	31	BG	15	10	30	10	55		.1670	21	H
	4Y	2000	24	15	103	14	5	31	BG	20	10	35	10	45		.1718	28	H
	4Z	2000	24	15	103	14	5	31	BG	20	10	20	16	60		.1785	32	H
	4AA	2000	24	15	103	14	5	31	BG	45	27	15	16	40		.1920	36	H
	4BB	2000	24	15	103	14	5	31	BG	10	15	15	20	75		.2025	38	H
	4CC	2000	24	15	100	15	5	31	BG	20	10	30	8	50		.1950	43	H
	4DD	2000	24	15	100	15	5	31	BG			45	13	55		.1881	48	H
	5A	2000	24	15	107	19	4	31	BG			100	10			.0117	25	H
	5B	2000	24	15	107	19	4	31	BG			80	12	20		.0160	21	H
	5C	2000	24	15	107	19	4	31	BG			40	10	60		.0166	21	H
	5D	2000	24	15	107	19	4	31	BG			100	10			.0150	9	H
	5E	2000	24	15	107	19	4	31	BG			60	16	40		.0200	20	H
	5F	2000	24	15	107	19	4	31	BG			100	16			.0184	70	H
	5G	2000	24	15	107	19	4	31	BG			85	12	15		.0200	[illegible]	H
	5H	2000	24	15	107	19	4	31	BG			100	15			.0184	83	[illegible]
	5I	2000	24	15	107	19	4	31	BG			60	15	40		.0167	98	H
	5J	2000	24	15	107	19	4	31	BG	60	10	40	14			.0200	40	H
76	1A	1400	24	12	85	22	10	13	T	60	12	40	5			.0329	115	H
	1B	1400	24	12	85	22	10	13	T	60	10			40		.0100	99	H
	1C	1400	24	12	85	22	10	13	T	70	10			30		.0083	83	H
79	3A	1800	24	9	105	14	5	14	GB	50	10	60	10			.0128	90	H
	3B	1800	24	[illegible]	105	14	5	14	GB	20	14	60	18	20		.0317	98	H

GROUP IV—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
79	3C	1800	24	9	105	14	5	14	6B	30	23	30	13	40		.0500	105	H
	3D	1800	24	9	103	15	5	14	6B	40	21	60	12			.0660	93	H
	3E	1800	24	9	103	15	5	14	6B	30	25	60	12	10		.0816	90	H
	3F	1800	24	9	103	15	5	14	6B	70	20	20	12	10		.0916	88	H
	3G	1800	24	9	103	15	5	14	6B	35	20	45	12	20		.0965	83	H
	3H	1800	24	9	100	16	5	14	6B	10	18	75	13	15		.1160	77	H
	3I	1800	24	9	100	16	5	14	6B	15	18	65	11	20		.1069	76	H
	3J	1800	24	9	103	15	5	14	6B	20	19	60	15	20		.1050	64	H
	3K	1800	24	9	103	15	5	14	6B	20	22	25	16	55		.0976	60	H
83	3A	1600	24	10	72	7	3	23	B			20	10	80		1100	8	H
	3B	1600	24	10	71	7	3	33	B	10	25	40	14	50		.1340	6	H
	3C	1600	24	10	68	8	3	33	B	20	17	20	11	60		.1699	5	H
	3D	1600	24	10	68	8	3	33	B	20	16	40	10	40		.1775	0	H
	3E	1600	24	10	69	7	3	33	B	10	22	45	16	45		.1680	10	H
	3F	1600	24	10	68	8	3	33	B	10	16	40	21	50		.1250	4	H
	3G	1600	24	10	69	7	3	33	B	20	15	50	17	30		1105	6	H
	3H	1600	24	10	67	8	3	33	B	30	18	45	18	25		.0989	10	H
	3I	1600	24	10	68	8	3	33	B	40	15	30	13	30		.0880	10	H
	3J	1600	24	10	69	7	3	33	B	10	13	30	18	60		.0853	10	H
	4A	1600	24	2	70	5	3	14	B	35	15	30	13	35		.1194	10	H
	4B	1600	24	2	70	5	3	14	B	25	17	45	12	30		.0983	71	H
	4C	1600	24	2	71	5	3	14	B	20	20	50	15	[illegible]		.0890	66	H
	4D	1600	24	2	70	5	3	14	B	30	17	25	20	60		.0655	54	H
	4E	1600	24	2	72	5	3	14	B	25	22	35	17	40		.0576	50	H
	4F	1600	24	2	72	5	3	14	B	15	16	55	20	30		.0490	42	H
	4G	1600	24	2	72	5	3	14	B	10	16	60	14	30		.0420	37	H
	4H	1600	24	2	72	5	3	14	B	50	12	50	16			.0366	24	H
	4I	1600	24	2	72	4	3	14	B	15	24	50	16	35		.0314	21	H
	4J	1600	24	2	74	3	3	14	B	10	14	75	10	15		.0341	18	H
	4K	1600	24	2	73	4	3	14	B	25	10	25	14	50		.0498	10	H
	4L	1600	24	2	73	4	3	14	B	25	22	45	10	30		.0630	12	H
	4M	1600	24	2	70	5	3	14	B	40	14	25	16	35		.0655	15	H
	4N	1600	24	2	70	5	3	14	B	45	16	20	25	35		.0610	18	H
	4O	1600	24	2	68	6	3	14	B	70	17	20	21	10		.0550	23	H
	4P	1600	24	2	68	6	3	14	B	30	20	35	14	25		.0530	25	H

GROUP IV—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
83	4Q	1600	24	2	70	5	3	14	B	15	20	75	15	10		.0455	29	H
	4R	1600	24	2	66	6	3	14	B	50	12	35	15	15		.0393	25	H
84	3K	1600	24	10	67	8	3	33	B	80	14			20		.0231	171	H
	3L	1600	24	10	67	8	3	33	B	70	28			30		.0237	162	H
	3M	1600	24	10	66	8	3	33	B	86	15			15		.0237	164	H
	3N	1600	24	10	67	8	3	33	B	75	17			25		.0229	170	H
	3O	1600	24	10	69	7	3	33	B	100	12					.0208	140	H
	3P	1600	24	10	67	8	3	33	B	70	22	10	18	20		.0213	141	H
	3Q	1600	24	10	67	8	3	33	B	100	16					.0213	160	H
	3R	1600	24	10	68	8	3	33	B	75	25	10	22	15		.0213	170	H
	3S	1600	24	10	69	7	3	33	B	60	14			40		.10	165	H
	3T	1600	24	10	71	7	3	33	B	35	18	16	22	50		.0206	152	H
	4S	1600	24	2	65	7	3	14	B	45	20	30	23	25		.0735	168	H
	4T	1600	24	2	67	6	3	14	B	30	19	40	26	30		.0537	173	H
	4U	1600	24	2	64	7	3	14	B	25	10	10	30	15		.0320	177	H
	4V	1600	24	2	65	7	3	14	B	100	14					.0215	176	H
	4W	1600	24	2	65	7	3	14	B	30	10			70		.0170	168	H
	4X	1600	24	2	65	7	3	14	B	100	10					.0192	162	H
	4Y	1600	24	2	63	8	3	14	B	70	15	30	10			.0249	155	H
	4Z	1600	24	2	65	7	3	14	B	55	12			45		.0361	162	H
	4A'	1600	24	2	65	7	3	14	B	40	13	30	10	40		.0635	165	H
	4B'	1600	24	2	64	7	3	14	B	45	10	25	10	30		.0785	166	H
	4C'	1600	24	2	64	7	3	14	B	40	10	10	10	50		.0970	168	H
87	1A	1800	24	13	93	19	3.5	33	T	100	16					.0117	140	F
	1B	1800	24	13	93	19	3.5	33	T	65	10			35		.0424	79	F
	1C	1800	24	13	93	19	3.5	33	T	20	10			80		.1116	70	H
	1D	1800	24	13	93	19	3.5	33	T	20	11			80		.1225	[illegible]	H
	1E	1800	24	13	93	19	3.5	33	T	15	11			85		.1415	45	H
	1F	1800	24	13	93	19	3.5	33	T	30	10			70		.1688	11	H
	1G	1800	24	13	93	19	3.5	33	T	65	6			35		.1365	2	H
	1H	1800	24	13	93	19	3.5	33	T	35	10			65		.0657	28	F
	2A	1800	24	4	89	22	8.5	9	T	65	10	35	10			.0831	38	H
	2B	1800	24	4	89	22	8.5	9	T	30	10	70	10			.0540	44	H
	2C	1800	24	2	89	22	8.5	9	T			100	10			.0083	51	H
	3A	1800	24	5	87	12	5	11	T					100		.0125	30	H

GROUP IV—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI	Fuel	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
87	3B	1800	24	5	87	12	5	11	T			35	12	65		.0366	18	H
	3C	1800	24	5	87	12	5	11	T			80	10	20		.0192	24	H
	4A	1800	24	6	87	12	5	12	T	60	13	40	10			.0449	27	F
	4B	1800	24	6	87	12	5	12	T			100	10			.0423	3	F
	4C	1800	24	6	87	12	5	12	T					100		.0350	60	F
	4D	1800	24	6	87	12	5	12	T	30	10			70		.0366	41	F
	5A	1800	24	6	87	16	5	12	T			45	10	55		.0450	19	H
	5B	1800	24	6	87	16	5	12	T			100	10			.0158	45	H
	5C	1800	24	6	87	16	5	12	T					100		.0691	64	H
	5D	1800	24	6	87	16	5	12	T	50	10	30	10	20		.0681	101	F
	6A	1800	24	7	85	24	5.5	12	T					100		.0108	119	H
	6B	1800	24	7	85	24	5.5	12	T			100	10			.0067	132	H
	6C	1800	24	7	85	24	5.5	12	T					100		.0294	165	H
	7A	1800	24	6	90	17	5	14	T					100		.0100	46	H
	7B	1800	24	6	90	17	5	14	T					100		.0075	26	H
	7C	1800	24	6	90	17	5	14	T	100	10					.0083	40	H
	8A	1800	24	9	92	16	4.5	22	[illegible]			100	10			.0167	20	H
	8B	1800	24	9	92	16	4.5	22	T			100	10			.0200	1	H
	8C	1800	24	9	92	16	4.5	22	T	35	10	20	10	45		.0291	14	H
	8D	1800	24	9	92	16	4.5	22	T			30	10	70		.0409	20	H
88	2A	0000	24	17	100	28	6	27	T					100		.0220	85	F
	2B	0000	24	17	101	28	6	27	T	55	14	45	10			.0216	75	F
	2C	0000	24	17	98	29	6	27	T	65	6			35		.0279	43	F
	2D	0000	24	17	94	30	6	27	T	100	9					.0430	21	H
	2E	0000	24	17	93	30	6	27	T	65	20			35		.0642	12	H
	2F	0000	24	17	93	31	6	27	T	80	14			20		.0736	2	H
	2G	0000	24	17	97	29	6	27	T	100	12					.0088	[illegible]	F
	3A	0000	24	4	85	21	6	9	T	65	8	35	10			[illegible]	53	
	3B	0000	24	4	84	21	6	9	T	60	14	40	10			.0142	85	H
	3C	0000	24	4	83	22	6	9	T					100		.0112	155	H
	3D	0000	24	4	82	22	6	9	T					100		.0067	135	H
	3E	0000	24	4	83	22	6	9	T	45	10	55	10			.0142	148	H
	3F	0000	24	4	82	22	6	9	T					100		.0112	144	H
	3G	0000	24	4	79	23	6	9	T			100	10			.0033	57	R
	3H	0000	24	4	80	23	6	9	[illegible]			100	10			[illegible]	39	R

GROUP IV. 24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
88	3I	0000	24	4	80	23	6	9	T			100	17			.0042	36	R
	4A	0000	24	5	84	21	6	9	T	60	13	40	10			.0108	67	H
	4C	0000	24	5	84	21	6	9	T					100		.0158	68	H
	4C	0000	24	5	85	22	6	9	T	55	13	45	10			.0075	62	H
	5[illegible]	0000	24	7	80	18	6	13	T					100		.0160	125	F
	5B	0000	24	7	80	18	6	13	T	50	15			50		.0179	147	F
	6A	0000	24	6	75	20	6	9	T	100	20					.0071	147	R
	6B	0000	24	6	75	20	6	9	--	100	10					.0030	143	R
	6C	0000	24	6	75	20	6	9	T	100	10					.0067	129	R
90	2A	0800	24	24	71	12	4	84	B	100	12					.0117	152	R
	2B	0800	24	24	71	12	4	84	B					100		.0075	170	R
	2C	0800	24	24	74	11	4	84	B	70	14	30	16			.0142	162	R
	2D	0800	24	24	77	10	4	84	B	70	21	30	14			.0092	148	R
	2E	0800	24	24	78	9	4	84	B	60	10	40	7			.0184	139	R
91	2A	0800	24	24	76	10	4	84	B	35	13	35	17	30		.1300	44	H
	2B	0800	24	24	75	10	4	84	B	40	18	40	14	20		.1429	46	H
	2C	0800	24	24	73	11	4	84	B	40	24	45	16	15		.0530	54	F
	2D	0800	24	24	73	12	4	84	B	20	14	80	15			.0457	51	F
	2E	0800	24	24	72	12	4	84	B	25	9	75	10			.0544	61	F
	2F	0800	24	24	71	12	4	84	B	30	11	45	8	25		.0417	61	F
	2G	0800	24	24	72	12	4	84	B	25	8	35	9	40		.0300	69	F
	3A	0800	24	28	78	7	4	84	B	50	13	25	15	25		.0264	87	F
	3B	0800	24	28	78	7	4	84	B	25	13	30	13	45		.0655	101	F
	3C	0800	24	28	79	6	4	84	B	15	22	40	20	45		.0585	92	F
	3D	0800	24	28	80	6	4	84	B	55	22	45	14			.0515	109	F
	3E	0800	24	28	76	10	4	84	B	50	17	40	17			.0396	103	F
96	6A	2400	24	12	79	14	4.5	27	TB	[illegible]	19	25	11	55		.0450	13	[illegible]
	6B	2400	24	12	78	14	4.5	27	TB	55	10	25	10	20		.0425	12	H
	6C	2400	24	1.	78	14	4.5	27	TB	35	14			65		.0358	5	H
	6D	2400	24	12	76	15	4.5	27	TB	10	19			90		.0225	18	H
	6E	2400	24	12	75	15	4.5	27	TB	70	19	30	25			.0208	22	H
	6F	2400	24	12	75	15	4.5	27	TB	30	22	40	14	30		.0200	48	H
	6G	2400	24	12	75	15	4.5	27	TB	45	11			55		.0384	29	H
	6H	2400	24	-	74	15	4.5	27	TB	40	10			60		.0391	37	H
	7A	2400	24	15	84	15	4.5	29	TB	40	10			60		.0125	24	F

GROUP [illegible] Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
96	7B	2400	24	15	83	15	4.5	29	TB	55	17	25	18	20		.0125	17	F
	7C	2400	24	15	83	15	4.5	29	TB	25	22			75		.0100	2	F
	7D	2400	24	15	82	15	4.5	29	TB	100	16					.0083	13	H
	7E	2400	24	15	83	15	4.5	29	TB	100	19					.0058	35	H
	[illegible]	2400	24	15	82	15	4.5	29	TB	45	18	25	10	30		.0308	31	H
	7G	2400	24	15	81	16	4.5	29	TB	50	12	[illegible]	13	40		.0425	17	H
	7H	2400	24	15	81	16	4.5	29	TB	45	12	25	10	30		.0517	11	H
98	3A	1800	24	15	91	40	8	13	B					100		.0917	28	F
	3B	1800	24	15	91	40	8	13	B					100		.0416	33	H
	3C	1800	24	15	91	40	8	13	B					100		.1417	10	H
	3D	1800	24	15	91	40	8	13	B					100		.0833	38	H
	3E	1800	24	15	91	40	8	13	B					100		.0600	25	F
	3F	1800	24	15	91	40	8	13	B					100		.2250	15	H
	3G	1800	24	15	91	40	8	13	B					100		.0750	45	F
	3H	1800	24	15	91	40	8	13	B					100		.0750	45	F
	3I	1800	24	15	91	40	8	13	B					100		.0667	59	F
	4A	1800	24	15	91	41	8	13	B					100		.3833	7	H
99	1A	0600	24	9	72	40	7	8	B					100		.0416	24	F
	1B	0600	24	9	72	40	7	8	B					100		.0350	27	F
	1C	0600	24	9	72	40	7	8	B					100		.0333	31	F
	1D	0600	24	9	72	40	7	8	B					100		.0208	33	F
	1E	0600	24	9	72	40	7	8	B					[illegible]		.0158	41	F
	2A	0600	24	10	76	57	7.5	6	B					100		.0317	85	H
	2B	0600	24	10	76	57	7.5	6	B					100		.0250	82	H
	2C	0600	24	10	76	57	7.5	6	B					100		.0200	72	H
	2D	0600	24	10	76	57	7.5	6	B					100		.0150	62	H
	2E	0600	24	10	76	57	7.5	6	B					100		.0100	77	H
	2F	0600	24	10	76	57	7.5	6	B					100		.0075	69	H
	2G	0600	24	10	76	57	7.5	6	B					100		.0042	69	F
101	2A	1800	24	11	67	34	8.0	12	H			20	10	80		.0151	164	H
	2B	1800	24	11	67	34	8.0	12	H	50	10	20	10	30		.0110	169	H
	2C	1800	24	11	67	34	8.0	12	H					100		.0127	179	H
	2D	1800	24	11	67	34	8.0	12	H					100		.0140	167	H
	2E	1800	24	11	67	34	8.0	12	H	20	11	30	10	50		.0151	159	H
	2F	1800	24	11	67	34	8.0	12	H	15	10	15	10	[illegible]		.0201	153	H

GROUP IV—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY: SLOPE UP		SLOPE DOWN				SPREAD		
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	Fuel	%	Aver Deg.	%	Aver Deg	Pct. Flat	Sketch	Rate	Angle to Wind	Type
101	2G	1800	24	11	67	34	8.0	12	H	25	10	15	10	60		.0218	162	H
	2H	1800	24	11	67	34	8.0	12	H	35	15	10	10	55		.0219	151	H
	2I	1800	24	11	67	34	8.0	12	H	25	10			75		.0220	151	H
	2J	1800	24	11	67	34	8.0	12	H	30	10	20	10	50		.0222	147	H
	2K	1800	24	11	67	34	8.0	12	H	45	10	40	10	15		.0194	165	H
	2L	1800	24	11	67	34	8.0	12	H	30	10	30	10	40		.0196	169	H
	2M	1800	24	11	67	34	8.0	12	H	30	10	70	10			.0221	161	H
	2N	1800	24	11	67	34	8.0	12	H	25	10	75	10			.0199	155	H
	2O	1800	24	11	67	34	8.0	12	H	15	10	40	10	45		.0164	155	H
	2P	1800	24	11	67	34	8.0	12	H					100		.0106	138	H
	2Q	1800	24	11	67	34	8.0	12	H					100		.0103	125	F
	2R	1800	24	11	67	34	8.0	12	H					100		.0128	107	F
	2S	1800	24	11	67	34	8.0	12	H					100		.0133	74	F
	2T	1800	24	11	67	34	8.0	12	H	10	11			90		.0156	60	F
	2U	1800	24	11	67	34	8.0	12	H	25	10	75	10			.0164	53	F
	2V	1800	24	11	67	34	8.0	12	H					100		.0179	39	R
	2W	1800	24	11	67	34	8.0	12	H					100		.0191	30	R
	2X	1800	24	11	67	34	8.0	12	H	45	10	10	10	45		.0191	25	R
	2Y	1800	24	11	67	34	8.0	12	H	35	10			65		.0209	27	R
	3A	1800	24	3	64	44	8.5	5	H					100		.0037	94	F
	3B	1800	24	3	64	44	8.5	5	H	60	16			40		.0040	91	F
	3C	1800	24	3	64	44	8.5	5	H	80	14			20		.0063	111	F
	3D	1800	24	3	64	44	8.5	5	H	20	11	40	15	4[illegible]		.0056	121	F
	3E	1800	24	3	64	44	8.5	5	H			60	10	40		.0060	129	F
	3F	1800	24	3	64	44	8.5	5	H			40	16	60		.0060	136	H
	3G	1800	24	3	64	44	8.5	5	H			100	15			.0074	160	H
	3H	1800	24	3	64	44	8.5	5	H			75	17	25		.0076	1[illegible]3	H
	3I	1800	24	3	64	44	8.5	5	H			100	10			.0077	135	H
	3J	1800	24	3	64	44	8.5	5	H			100	10			.0085	121	F
	3K	1800	24	3	64	44	8.5	5	H			80	12	20		.0087	82	O
	3L	1800	24	3	64	44	8.5	5	H			70	15	30		.0090	101	O
	3M	1800	24	3	64	44	8.5	5	H			100	15			.0089	112	O
	3N	1800	24	3	64	44	8.5	5	H			100	10			.0076	117	O
	3O	1800	24	3	64	44	8.5	5	H			100	14			.0068	126	O
	3P	1800	[illegible]	3	64	44	8.5	5	H			100	10			.0058	135	O

GROU[illegible]our Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
101	3Q	1800	24	3	64	44	8.5	5	H			100	10			.0052	101	0
	3R	1800	24	3	64	44	8.5	5	H					100		.0052	139	0
	3S	1800	24	3	64	44	8.5	[illegible]	H			40	10	60		.0050	129	0
	3T	1800	24	3	64	44	8.5	5	H			100	10			.0060	105	0
	3U	1800	24	3	64	44	8.5	5	H			[illegible]	10	30		.0071	117	0
	3V	1800	24	3	64	44	8.5	5	H			30	11	70		.0082	150	0
	3W	1800	24	3	64	44	8.5	5	H	20	11	60	11	20		.0082	133	0
	3X	1800	24	3	64	44	8.5	5	H	35	10	25	10	40		.0089	160	0
	3Y	1800	24	3	64	44	8.5	5	H	50	10	10	10	40		.0108	155	0
	3Z	1800	24	3	64	44	8.5	5	H	20	10			80		.0142	160	0
	3A'	1800	24	3	64	44	8.5	5	H	20	10			80		.0171	160	0
	3B'	1800	24	3	64	44	8.6	5	H	35	10	40	10	25		.0260	167	0
	3C'	1800	24	3	64	44	8.5	5	H	20	10			80		.0329	173	0
	3D'	1800	24	3	64	44	8.5	5	H	15	10			85		.0350	178	0
	3E'	1800	24	3	64	44	8.5	5	H	15	10			85		.0376	179	0
	3F'	1800	24	3	64	44	8.5	5	H					100		.0368	175	0
	3G'	1800	24	3	64	44	8.5	5	H	15	10	20	10	65		.0382	175	0
	3H'	1800	24	3	64	44	8.5	5	H	30	10	25	10	45		.0360	172	0
	3I'	1800	24	3	64	44	8.5	5	H	40	10	50	10	10		.0318	163	0
	3J'	1800	24	3	64	44	8.5	5	H	45	10			55		.0329	156	0
	3K'	1800	24	3	64	44	8.5	5	H	15	10	30	10	55		.0348	148	0
	3L'	1800	24	3	64	44	8.5	5	H					[illegible]		[illegible]	153	0
	3M'	1800	24	3	64	44	8.5	5	H					[illegible]		.0380	141	0
	3N'	1800	24	3	64	44	8.5	5	H			35	10	65		.0394	135	0
	3O'	1800	24	3	64	44	8.5	5	H			25	10	75		.0390	126	0
	3P'	1800	24	3	64	44	8.5	5	H	25	10	60	10	15		[illegible]	[illegible]	0
	3Q'	1800	24	3	64	44	8.5	5	H	15	10	50	10	35		.0376	114	[illegible]
	3R'	1800	24	3	64	44	8.5	5	H	15	10	15	10	70		.0369	117	0
	3S'	1800	24	3	64	44	8.5	5	H	30	10	30	10	40		.0360	116	0
	3T'	1800	24	3	64	44	8.5	5	H					100		.0340	124	0
	3U'	1800	24	3	64	44	8.5	5	H					100		.0310	132	0
	3V'	1800	24	3	64	44	8.5	5	H			15	10	85		.0216	130	0
	3W'	1800	24	3	64	44	8.5	5	H			15	10	85		.0192	133	0
	3X'	1800	[illegible]	3	64	44	8.5	5	[illegible]					100		.0174	131	0
	3Y'	[illegible]	24	3	64	44	8.5	5	H					[illegible]		.0168	122	0

GROUP [illegible] -24 Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
101	4A	1800	24	3	85	38	7.5	6	H			50	10	50		.0087	97	0
	4B	1800	24	3	85	38	7.5	6	H					100		.0060	93	0
	4C	1800	24	3	85	38	7.5	6	H					100		.0074	88	0
	4D	1800	24	3	85	38	7.5	6	H					100		.0079	90	0
	4E	1800	24	3	85	38	7.5	6	H					100		.0100	99	0
	4F	1800	24	3	85	38	7.5	6	H			[illegible]	[illegible]	80		.0126	105	0
	4G	1800	24	3	85	38	7.5	6	H			10	7	80		.0142	109	0
	4H	1800	24	3	85	38	7.5	6	H					100		.0150	15	0
	4I	1800	24	3	85	38	7.5	6	H					100		.0092	157	0
	4J	1800	24	3	85	38	7.5	6	H					100		.0108	162	0
	4K	1800	24	3	85	38	7.5	6	H					100		.0095	153	0
	4L	1800	24	3	85	38	7.5	6	H	25	12			75		.0090	147	0
	4M	1800	24	3	85	38	7.5	6	H	15	10			75		.0087	141	0
	4N	1800	24	3	85	38	7.5	6	H					100		.0092	133	0
	4O	1800	24	3	85	38	7.5	6	H			15	10	85		.0103	175	0
	4P	1800	24	3	85	38	7.5	6	H					100		.0108	122	0
	4Q	1800	24	3	85	38	7.5	6	H			30	10	70		.0110	118	0
	4R	1800	24	3	85	38	7.5	6	H			15	10	85		.0105	105	0
	4S	1800	24	3	85	38	7.5	6	H			15	12	85		.0092	98	0
	4T	1800	24	3	85	38	7.5	6	H			40	12	60		.0074	98	0
	4U	1800	24	3	85	38	7.5	6	H			15	10	85		.0063	92	0
	4V	1800	24	3	85	38	7.5	6	H					[illegible]		.0037	107	0
	4W	1800	24	3	85	38	7.5	6	H					100		.0074	107	0
	4X	1800	24	3	85	38	7.5	6	H					100		.0026	111	0
	4Y	1800	24	3	85	38	7.5	6	H					100		.0029	121	0
	4Z	1800	24	3	85	38	7.5	6	H			100	9			.0022	134	0
	4A'	1800	24	3	85	38	7.5	6	H			45	12	55		.0037	150	[illegible]
	4B'	1800	24	3	85	38	7.5	6	H					100		.0053	145	0
	4C'	1800	24	[illegible]	85	38	7.5	6	H					100		.0066	132	0
	4D'	1800	24	3	85	38	7.5	6	H					100		.0058	131	0
	4E'	1800	24	3	85	38	7.5	6	H					[illegible]		.0053	136	0
	4F'	1800	24	3	85	38	7.5	6	H					[illegible]		.0050	128	0
	4G	1800	24	3	85	38	7.5	6	H					100		.0037	142	0
	5A	1800	24	3	80	44	8	7	H					100		.0060	87	0
	5B	1800	24	[illegible]	80	44	8	7	H	10	[illegible]	10	10	[illegible]		.0071	93	0

GROUP I. -2 " · Periods

FIRE				WEATHER					FUEL	TOPOGRAPHY						SPREAD		
										SLOPE UP		SLOPE DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver Deg.	%	Aver Deg	Percent Flat	Sketch	Rate	Angle to Wind	Type
101	5C	1800	24	8	80	44	8	7	H	10	10	10	10	80		.0075	96	O
	5D	1800	24	8	80	44	8	7	H					100		.0074	70	O
	5E	1800	24	8	80	44	8	7	H					100		.0079	63	O
	5F	1800	24	8	80	44	8	7	H					100		.0079	17	O
	5G	1800	24	8	80	44	8	7	H					100		.0053	60	O
	5H	1800	24	8	30	44	8	7	H					100		.0032	56	O
	5I	1800	24	8	80	44	8	7	H					100		.0037	74	O
	5J	1800	24	8	80	44	8	7	H					100		.0058	87	O
103	1A	0000	24	9	67	65	10.5	3	H					100		.0972	4	H
	1B	0000	24	9	67	65	10.5	3	H					100		.0892	0	H
	1C	0000	24	9	67	65	10.5	3	H					100		.0850	3	H
	1D	0000	24	9	67	65	10.5	3	H					100		.0792	89	H
	2A	0000	24	7	66	68	11.0	2	H					100		.0726	141	H
	2B	0000	24	7	66	68	11.0	2	H					100		.0930	138	H
	4A	0000	24	5	78	31	6.5	7	H					100		.0176	103	H
	4B	0000	24	5	78	31	6.5	7	H					100		.0125	114	H
	5A	0000	24	6	66	43	7.5	5	H					100		.0021	72	H
	5B	0000	24	6	66	43	7.5	5	H					100		.0058	46	H
	5C	0000	24	6	66	43	7.5	5	H					100		.0108	44	H
106	2A	0000	24	8	98	12	3.5	22	T	60	13	40	15			.0725	159	H
	2B	0000	24	8	97	13	3.5	22	T	65	13	35	15			.0687	154	H
	2C	0000	24	8	96	13	3.5	22	T	40	17	60	.4			.0725	138	H
	2D	000	24	8	96	13	3.5	22	T	30	20	20	11	50		.0646	133	H
	2E	0000	24	8	96	13	3.5	22	T	70	11	30	4			.0646	125	H
	2F	0000	24	8	96	13	3.5	22	T	100	10					.0770	121	H
107	2A	0000	24	6	95	14	4	20	T					100		.0167	105	F
	2B	0000	24	6	95	14	4	20	T					100		.0375	97	[illegible]
	2C	0000	24	6	95	14	4	20	T					100		.0583	87	H
	2D	0000	24	6	96	14	4	20	T	80	11			70		.0625	81	H
	2E	0000	24	6	96	13	4	20	T					100		.0625	73	H
	2F	0000	24	6	97	13	4	20	T					100		.0771	71	H
	2G	0000	24	6	93	15	4	20	T					100		.0771	76	H
	2H	0000	24	6	95	14	4	20	T	100	10					.0625	70	H
	2I	0000	24	6	95	14	4	20	T	70	11	30	15			.0646	62	H
	2J	000	24	6	103	11	4	20	T			75	16	25		.0416	10	H

GROUP I 24 Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No.	Time of Start	Hours of Spread	Wind Vel.	Temp	RH	Stick	BI	FUEL	%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
107	2K	0000	24	6	106	10	4	20	T			80	12	20		.0562	4	H
	2L	0000	24	6	105	10	4	20	T			50	11	50		.0645	6	H
	2M	0000	24	6	105	10	4	20	T			45	10	65		.0687	8	H
	2N	0000	24	6	105	10	4	20	T			40	15	60		.0625	16	H
	2O	0000	24	6	100	12	4	20	T			25	18	75		.0521	22	H
	2P	0000	24	6	103	11	4	20	T			100	10			.0146	50	F
	2Q	0000	24	6	101	12	4	20	T					100		.0208	73	F
	2R	0000	24	6	102	12	4	20	T					100		.0208	89	F
	2S	0000	24	6	101	12	4	20	T	100	7					.0208	99	F
108	2A	1800	24	10	85	27	5.5	17	T			100	22			.0104	3	O
	2B	1800	24	10	85	27	5.5	17	T			100	10			.0192	32	O
	2C	1800	24	10	85	27	5.5	17	T					100		.0167	63	O
	3A	1800	24	6	84	30	6.5	9	T	45	15	55	14			.0317	144	F
	3B	1800	24	6	84	30	6.5	9	T	40	14	60	15			.0313	103	F
	3C	1800	24	6	84	30	6.5	9	T					100		.0676	25	H
	3D	1800	24	6	84	30	6.5	9	T			100	10			.0631	16	H
	3E	1800	24	6	84	30	6.5	9	T			100	10			.0279	8	H
	4A	1800	24	4	76	17	4	12	T			100	10			.0184	108	F
	4B	1800	24	4	76	17	4	12	T			100	10			.0279	124	F
109	2A	0000	24	7	87	29	7	7	T			100	31			.0036	115	R
	2B	0000	24	7	87	29	7	7	T			100	30			.0066	103	R
	2C	0000	24	7	87	29	7	7	T			100	21			.0120	102	R
	2D	0000	24	7	87	29	7	7	T			100	25			.0162	96	R
	2E	0000	24	7	86	30	7	7	T			100	28			.0114	36	R
	2F	0000	24	7	82	31	7	7	T			100	25			.0042	82	R
	2G	0000	24	7	82	31	7	7	T			100	17			.0025	30	R
	2H	0000	24	7	82	31	7	7	T			100	15			.0021	24	[illegible]
	2I	0000	24	7	82	31	7	7	T					100		.0062	23	R
	2J	0000	24	[illegible]	79	33	7	7	T	25	27	20	24	55		.0055	23	F
	2K	0000	24	7	80	32	7	7	T	30	20	20	20	50		.0218	27	F
	2L	0000	24	7	84	32	7	7	T	70	20	20	16	10		.0141	22	H
	2M	0000	24	7	82	31	7	7	T	15	20	30	22	55		.0094	13	F
	2N	0000	24	7	83	29	7	7	T	100	30					.0052	9	H
	2O	0000	24	[illegible]	83	29	7	7	T	100	35					.0031	15	H
	3A	0000	24	3	70	20	7	9	T			100	18			.0156	35	O

GROUP [illegible]—24-Hour Periods

FIRE				WEATHER						TOPOGRAPHY						SPREAD		
										SLOPE								
										UP		DOWN						
Fire No.	Line No	Time of Start	Hours of Spread	Wind Vel.	Temp.	RH	Stick	BI		%	Aver. Deg.	%	Aver. Deg.	Percent Flat	Sketch	Rate	Angle to Wind	Type
109	3B	0000	24	3	89	21	7	9	T			100	20			.0156	8	O
	3D	0000	24	3	89	21	7	9	T			100	10			.0135	2	O
	3E	0000	24	3	91	20	7	9	T	15	16	15	16	70		.0140	15	O
	3F	0000	24	3	91	20	7	9	T	100	10					.0186	40	O
	4A	0000	24	4	98	16	5	10	T			100	10			.0047	7	F
	4B	0000	24	4	98	16	5	10	T			100	10			.0161	29	H
	4C	0000	24	4	98	16	5	10	G			100	10			.0161	52	H
	4D	0000	24	4	98	16	5	10	G					100		.0177	74	H
	4E	0000	24	4	97	16	5	10	G			100	12			.0167	78	H
	4F	0000	24	4	98	16	5	10	T			100	26			.0094	95	F
	5A	0000	24	4	98	24	7	7	T			100	18			.0104	20	F
	5B	0000	24	4	98	24	7	7	T			100	20			.0093	25	F
	5C	0000	24	4	98	24	7	7	T			100	25			.0119	0	H
	5D	0000	24	4	99	24	7	7	T					100		.0156	21	H
	5E	0000	24	4	99	24	7	7	T			100	15			.0198	29	H
	5F	0000	24	4	99	24	7	7	T			40	18	60		.0218	41	H
	5G	0000	24	4	98	24	7	7	T			100	10			.0171	44	H
	5H	0000	24	4	98	24	7	7	T			100	20			.0093	57	F

Appendix E

Urban Fire Spread Data

The following tables contain rate-of-spread and associated data for large city fires. There is no standard length of time over which the rate of spread was calculated. For each fire studied, a rate of spread was calculated whenever two consecutive locations and times could be identified. Locations and times were noted more or less at random in the fire reports. Often this was when a particularly large or historic building caught fire. Actually this probably pegged the fire location accurately. Such definite landmarks are rare in most wildland areas

Explanation of Table Headings

FIRE

Name: City and State where fire occurred.

Date: Month, day, and year during which each particular fire spread occurred.

Period of Spread: Time of day fire arrived at a certain location and time fire had spread to a location farther on. Spread might be by spotting (firebrands) or ground spread as noted in Remarks.

Rate of Spread: Rate of fire spread, in miles per hour.

WEATHER

Temp.: Dry bulb temperature, in degrees Fahrenheit, usually for the beginning of the Period of Spread.

Wind speed: Measured wind velocity in miles per hour.

Wind dir.: Direction wind coming from to eight points of the compass.

Rel. humid.: Relative humidity in a standard U.S. Weather Bureau thermoscreen, in percent

Dryness: An adjective description of the weather factors before the fire which may have influenced the moisture content of fuels at the time of the fire.

BUILDINGS

T.: Type of building Numerical code, 1 to 4, to rate type of building construction and massiveness

B.: Builtupness. Percent of total ground area occupied by buildings.

S.: Number of stories in buildings.

V.: Structure value Numerical expression of relative rate of fire spread that integrates the factors of building type, builtupness, and number of stories. Structure value is a tentative rating of urban fuels as to relative rate of fire spread To rate any city area (fuel), identify the proper index number—1 to 4, as listed below—for each of the three fuel factors. Record the numbers, then add them. The sum is the Structure Value in a scale ranging from 3 to 12. The smaller the sum, the greater the relative rate of fire spread to be expected.

Type of Building

1. Light wooden
2. Heavy wooden
3. Light stone or concrete
4. Heavy stone or concrete

Builtupness

1. Very heavy (40 percent or more)
2. Heavy (30 to 39 percent)
3. Medium (20 to 29 percent)
4. Sparse (less than 20 percent)

Number of Stories

1. One
2. Two or three
3. Four to six
4. Seven or more

TOPOGRAPHY

Slope General slope of the ground and direction Fire spreading up slope is +. Fire spreading down slope is −. Fire spreading on level ground is 0.

REMARKS

Remarks: Short statements aimed to help interpret the data Usually indicates whether spread was by spotting (firebrands) or ordinary ground spread.

Fire		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. Humid.	Dryness	T	B	S	V		
Chicago, Illinois	3/15/22	0050-0230	0.063	40	13	N	65	Last rain 3-11 (Dry for season)	4-	40+	2-5	9	0	
Ottawa-Hull, Canada	4/26/00	1030-1300	0.212	60	30	N	70	Last rain 4-19 (.10in)	2	30-39	1	5	0	Spotting (Spread by)
	4/26/00	1300-1930	0.298	60	30	N	60		1	20-29	2-10	5	0	Spotting (Spread by)
Chicago, Illinois (Great)	10/9/71	2100-2200	0.227	67	4	SW	42	Extreme Drought	2	30-39	2	6	0	Spotting (Spread by)
	10/9/71	2200-2330	0.201	67	5	SW	44		3	20-29	4	8	0	
	10/9/71	2330-2400	0.419	67	5	SW	44		2	20-29	1	6	0	
	10/9/71	2400-0130	0.227	67	5	SW	45		3	30-39	4+	7	0	Spotting (Spread by)
	10/9/71	0130-0230	0.454	67	5	SW	46		3	20-29	3	8	0	
	10/9/71	0230-0300	0.932	67	5	SW	46		1	20-	2-3	6	0	
	10/9/71	0300-0320	0.624	67	4	SW	46		2	20-	2+	7	0	Spotting (Spread by)
	10/9/71	0700-0900	0.217	67	4	SW	49		2	20-29	1-10	7	0	Spotting (Spread by)
	10/9/71	0900-1200	0.327	67	6	SW	45		1	20-	1	6	0	Spotting (Spread by)
	10/9/71	1200-1700	0.265	82	7	SW	41		1	20-	1	6	0	

Fire		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. Humid.	Dryness	T	B	S	V		
San Francisco, California	4/18/06	1330-1530	0.047	60	20	W	45		2	30-39	2	6	0	Ground Spread
	4/18/06	1300-1500	0.331	60	20	W	45		2	30-39	2	6	0	Spotting (spread by) some incendiarism
	4/18/06	0600-1200	0.022	57	6-	W	65		2	30-39	2	6	0	U.S. Weather Bur. office burned 11.00 A.M. (Ground Spread)
	4/18/06	0900-1300	0.090	55	14	W	60		2	30-39	2-6	7	0	Ground Spread
	4/18-19/06	2100-0030	0.076	55	5	W	75		3	30-39	2.5	8	0	Ground Spread
	4/18/06	1000-1230	0.040	55	14	W	60		2	30-39	1	5	0	Ground Spread
	4/18/06	0530-1730	0.077	55	2-19	SW	55		2	30-39	3+	6	0	Ground Spread
	4/18/06	0530-1730	0.033	55	2-10	W	55		3	30-39	2	8	0	
	4/19/06	1900-2200	0.025	55	20	W			1	30-39	2	5	0	Ground Spread
	4/19/06	1130-1330	0.142	65	10	E			1	30-39	2	5	0	
	4/18/06	0600-1600	0.123	60	2-12	W	55		1	30-39	2-3	5	0	
	4/18/06	0900-2400	0.025	5[illegible]	5-19	W	60		1	30-39	2-3	5	0	Ground Spread
	4/20/06	0600-1800	0.063	60	26	W			2	30-39	2-3	6	0	

Fire		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. Humid.	Dryness	T	B	S	V		
Baltimore, Ohio	2/07/04	1050-2100	0.022	58-64	16	WSW	75	recent snow (still melting 2/7/04)	3	40+	6-10	8	0	Ground Spread, explosion spread blaze
	2/07/04	2100-2200	0.054	58-60	22	W	86		4	40+	8-16	9	0	Ground Spread
	2/07/04	2200-2345	0.331	53	22	NW	88		3	40+	8-10	8	0	Ground Spread
	2/07/04	2345-2350	3.175	50	20+	NW	88		3	40+	3	6	0	Spread by Spotting
Boston, Mass.	11/9/72	1900-2400	0.030	42	5-9	NNW	60	1.89" rain 11-7-72	3	40+	4	7	0	Ground Spread (Angle to wind [illegible] - most nearly with wind)
	11/9/72	1900-2400	0.042	42	5-9	NNW	60		3	40+	4	7	0	Ground Spread (Angle to wind = 080°)
	11/9/72	1900-2400	0.025	42	5-9	NNW	60		3	40+	4	7	0	Ground Spread (Angle to wind = 360° - most nearly into wind)
	11/9/72	1900-2400	0.030	42	5-9	NNW	60		3	40+	4	7	0	Ground Spread (Angle to wind = 290°)
Berkeley, Calif.	9/17/23	1420-1500	0.397	8[illegible]	25	NE	27	very Dry	1	20-29	2½	6	-6°	Spread by Spots
	9/17/23	1500-1600	0.454	89	28	NE	25	very Dry	1	20-29	2½	6	-6°	Spread by Spots
Atlanta, Ga.	5/21/17	1746-[illegible]	0.451	83-8[illegible]	14-16	S	43-	2 weeks since rain	1	20-29	1	5	0	Spread by Spots (Angle to wind = 000°)
	5/21/17	1130-1230	0.567	84-8[illegible]	16	S	35+		1	20-29	1	5	0	Spread by Spots (Angle to wind = 000°)

Fire		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. Humid.	Dryness	T	B	S	V		
Atlanta, Ga.	5/[illegible]/17	0400-0700	0.063	46-50	20	W	93	3 weeks since rain	3	40+	4	7	0	Ground Spread (Angle to wind = 090°)
Dorris, Calif.	7/28/34	1500-1600	0.497	86	24-27	SE	20	Dry	1	20-29	1	5	0	Spread by Spots (Angle to wind = 000°)
Augusta, Ga.	3/22/16	1820-2020	0.093	78-80	18-22	W	58	2 weeks without rain	3	30-39	1-5	8	0	Ground Spread (Angle to wind = 090°)
	3/22/16	2020-2030	4.526	78	18	NW	58		1	20-29	1	5	0	Spread by Spots (Angle to wind = 135°)
	3/22/16	2020-2030	2.835	78	18	NW	58		1	20-29	1	5	0	Spread by Spots (Angle to wind = 136°)
Nagasaki, Japan	8/9/45	1102-1502	0.156	75	3	NW	humid		3	20-29	1-3	8	0	Ground Spread
Fall River, Mass.	2/2/28	1730-1930	0.038	14	15	NW	55	wet	3	40+	6	7	0	Ground Spread (Angle to wind = 135°)
	2/2/28	1730-1945	0.017	14	17	SW	55		3	40+	4	7	0	Ground Spread (Angle to wind = 045°)
	2/2/28	1945-2015	0.076	14	18	S	55		3	40+	5	7	0	Ground Spread (Angle to wind = 340°)
	2/2/28	1945-2030	0.050	14	19	S	55		3	40+	4	7	0	Ground Spread (Angle to wind = 240°)
	2/2/28	2030-2330	0.015	14	22	S	55+		2	40+	1	4	0	Ground Spread (Angle to wind = 035°)

Fire		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. Humid.	Dryness	T	B	S	V		
Boston, Mass. Railroad Freight Shed	5/10/62	1555-1630	0.261	64	22-35	NW	6	Dry	1	20-	2	7	0	Ground Spread (Angle to wind = 135°)
	5/10/62	1600-1630	0.227	64	22-35	NW	6	↓	1	20-	1	6	0	Ground Spread (Angle to wind = 135°)
Chicago, Illinois Stockyard	5/19/34	1620-1645	0.369	92	15	SW	25	Very Dry	1	20-	1	6	0	Ground Spread (Angle to wind = 010°)
	5/19/34	1620-1645	0.507	92	15	SW	25	Very Dry	1	20-	1	6	0	Ground Spread (Angle to wind = 070°)
	5/19/34	1645-1700	0.499	92	15	SW	25	Very Dry	3	30-39	1-3	7	0	Spread by Spots (Angle to wind = 070°)
	5/19/34	1635-1715	0.095	92	15	SW	25	Very Dry	3	20-29	1-4	8	0	Ground Spread (Angle to wind = 070°)
	5/19/34	1620-1730	0.074	91	14	SW	25	Very Dry	1	20-	1	6	0	Ground Spread (Angle to wind = 070°)
	5/19/34	1730-1735	0.307	91	14	SW	25	Very Dry	3	20-29	1-3	8	0	Ground Spread (Angle to wind = 030°)
Camden, N.J.	7/30/40	1310-1730	0.014	76	15-21	SW	57	No rain in July	2	40+	5	6	0	Ground Spread (Angle to wind = 180°)
Chicago, Ill.	10/7/71	2230-2250	0.142	70	14	S	55	Very Dry	1	20-29	2	6	0	Ground Spread (Angle to wind = 000°)
Arverne, N.Y.	6/15/22	[illegible]15-1100	0.227	70	9	S	63	Last rain 6-11 Trace 9th & 16th	1	20-	2-3	7	0	Spread by Spots (Angle to wind = 000°)

File		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. Humid.	Dryness	T	B	S	V		
Bar[illegible]n, Oregon	9/26/36	2215-2235	1.474	70+	38	E	8	very Dry	1	20-	1-2	6	0	Spread by Spots (angle to wind = 270°)
	9/26/36	2235-2315	1.928	70+	38	E	8		1	20-	1-2	6	0	Spread by Spots (angle to wind = 270°)
	9/26/36	2245-2400	0.423	70+	38	E	8		2	20-29	1-2	6	0	Spread by Spots (angle to wind = 270°)
Paris, Texas	3/21/16	1730-1900	0.315	[illegible]1-95	27-29	S	26-	very Dry	1	20-29	1-2	5	0	Spread by Spots (angle to wind = 010°)
	3/21/16	1900-2100	0.047	87-91	27-29	S	26-		3	40+	4-6	7	0	Ground Spread (angle to wind = 000°)
	3/21/16	2100-2215	0.076	85-87	26-29	S	26-		3	40+	4-6	7	0	Ground Spread (angle to wind = 000°)
	3/21/16	2215-2245	0.095	83-85	26	S	26-		3	40+	4-6	7	0	Ground Spread (angle to wind = 000°)
	3/21/16	2245-2400	0.378	80-83	24-26	S	26-		1	20-29	1-2	5	0	Spread by Spots (angle to wind = 010°)
[illegible] New York, N.J.	8/18/61	1649-1659	2.999	80	8	N	49	Dry	2	20-	2-4	7	0	Spread by Spots
	8/18/61	1649-1714	0.095	77	8	N	56	Dry	2	20-29	2-4	7	0	Ground Spread
Asto[illegible], Oregon	12/8/22	0:12-0:45	0.034	35	16	S	100	Raining and snowing	2	30-39	1-3	6	0	Ground Spread (brands but no fires set)
	12/8/22	0:12-0300	0.047	35	29	S	100	Raining and snowing	2	30-39	1-3	6	0	Ground Spread (brands but no fires set)

Fire		Spread		Weather					Buildings				Slope	Remarks
Name	Date	Period	Rate	Temp	Wind Speed	Wind Dir.	Rel. humid.	Dryness	T	B	S	V		
Cleelom, Washington	6/25/18	1223-1600	0.219	75	15	W	X	Dry -.37" rain in June	1	30-39	1-2	4	0	Spread by Spots

GPO 957-435